Appendix I

FEDERAL RESTORATION PLAN

U.S. Department of the Interior

Part I: National Park Service

Part II: Bureau of Land Management

Clark Fork River Operable Unit,
Milltown Reservoir/Clark Fork River
National Priorities List Site

September 2007

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Part I: National Park Service

Federal Restoration Plan
for Grant-Kohrs Ranch National Historic Site

National Park Service
Grant-Kohrs Ranch National Historic Site
Deer Lodge, MT 59722

Clark Fork River Operable Unit,
Milltown Reservoir/Clark Fork River
National Priorities List Site

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LIST OF ACRONYMS

°F	degrees Fahrenheit
AERL	ARCO Environmental Remediation, L.L.C.
ARAR	Applicable or Relevant and Appropriate Requirements
ARCO	Atlantic Richfield Company
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
C.F.R.	Code of Federal Regulations
CFROU	Clark Fork River Operable Unit
cfs	cubic feet per second
COC	chemical of concern
cu yds	cubic yards
DC	direct current
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
EP&T	Ecological Planning and Toxicology, Inc.
FlowMaster	Haestad Methods Flowmaster
Foster Wheeler	Foster Wheeler Environmental Corporation
FS	Feasibility Study
ft	foot/feet
GRKO	Grant-Kohrs Ranch National Historic Site
IC	institutional control
mg/kg	milligrams per kilogram
NPS	National Park Service
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NRD	Natural Resource Damage
NRDA	Natural Resource Damage Assessment
Opportunity Ponds	Opportunity Ponds Waste Management Area
psf	pounds per square feet
RAO	Remedial Action Objective
RBC	risk-based concentration
RBZ	riparian buffer zone
ROA	Restoration Options Analysis
ROD	Record of Decision
RipES	Clark Fork River Riparian Evaluation System
TtFW	Tetra Tech FW, Inc.
USAEC	U.S. Army Environmental Center
U.S.C.	U.S. Code
USGS	U.S. Geological Survey
WSAHGP	Washington State Aquatic Habitat Guidelines Program

1. INTRODUCTION

Grant-Kohrs Ranch National Historic Site (GRKO), a unit of the National Park System located in Deer Lodge, Montana, is bisected by the Clark Fork River which was placed by the United States Environmental Protection Agency (USEPA) on the National Priorities List (NPL) in 1992 due to the release of mining-related hazardous substances. The Clark Fork River Operable Unit (CFROU) is part of the Milltown Reservoir/Clark Fork River NPL Site and constitutes a 120 mile segment within one of the largest Superfund complexes in the United States (Figure 1-1). In April 2004, with the concurrence of the National Park Service (NPS) and the State of Montana, the USEPA issued a Record of Decision (ROD) for the CFROU pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The ROD identifies the selected remedy to be implemented at the CFROU, including GRKO, to remedy the release or threat of release of hazardous substances (EPA 2004a).

NPS has complementary response action and natural resource trustee responsibilities for GRKO. NPS has identified injuries to natural resources at GRKO, assessed the resulting damages, and developed this Restoration Plan (Plan), the purpose of which is to describe the measures to be taken to restore injured natural resources at GRKO. This Plan describes the expected outcome of remedial action, identifies residual natural resource injury, and presents proposed measures to restore those injured resources. Additional detail will be developed as part of the design phase of the project.

Restoration measures will be distinguished from remedial action based on whether the activity is required to attain the performance standards of the ROD (and therefore constitutes remedial action) or is an additional measure necessary to achieve restoration objectives. Restoration measures will be complementary to, and implemented in concert with, the remedial action to reduce costs and resource impacts associated with contractor mobilization and soil disturbance.

This Plan is subject to public review, public comment, and finalization during the pendency of the approval process for the *Consent Decree for the Clark Fork River Operable Unit and for Remaining State of Montana Clark Fork Basin Natural Resource Damage Claims* ("Consent Decree"), and meets the substantive provisions of Restoration Planning as specified at 43 CFR 11.93.

1.1 Site Description

GRKO is located in Powell County, Montana, adjacent to the northern boundary of the City of Deer Lodge (Figure 1-2). An approximately 1,600-acre working cattle ranch, GRKO is located within the fertile Deer Lodge Valley and is drained by the Clark Fork River of the Columbia River Basin (Figure 1-3). The elevation of Deer Lodge is 4,500 feet (ft) above sea level (GRKO 1995).

GRKO's important cultural resources include 61 historic buildings, 27 other historic structures, and a large collection of artifacts, documents, and photographs related to ranch operations dating back to the 1860s. The furnishings of the main ranch house and bunkhouse (which are original and intact), along with a large assortment of horse-drawn farm and ranch vehicles and equipment, constitute a curatorial collection for exhibit and study of significant natural and cultural resources. The museum collection includes approximately 26,500 objects (GRKO 1995).

1.1.1 GRKO Management Zone

The following information is summarized from GRKO's *Statement for Management* (1995). The *Statement for Management* "documents the park's purpose, significance, management objectives, obstacles to achieving those objectives, owners of the obstacles, and actions that need to be taken to overcome the obstacles" (GRKO 1995, signature page).

The management zoning for GRKO provides a framework for decisions on use and development. The framework is based on three management zones—historic zone, development zone, and special use zone—with each divided into subzones to help focus on specific types of intended use and development.

The historic zone is the largest and most significant of the three zones and comprises about 81 percent of the lands within the park boundary. It is managed primarily to preserve cultural resources and historical land uses and to provide public appreciation of the cattle ranching heritage. Two subzones have been designated within the historic zone. The preservation/adaptive use subzone includes the home ranch area west of the railroad tracks as well as the mechanized feed operation to the east. The grazing/hay meadow subzone includes the grazing lands and meadows northwest of the main ranch complex. The historic zone is where the majority of visitor and worker activity occurs.

The development zone is an 11-acre parcel of land located near the southeast boundary and consists of an enlarged parking area, temporary visitor's center, and a curatorial facility.

The special use zone comprises about 18 percent of GRKO's acreage and includes improvements used by other interests. It includes three subzones: (1) a utility subzone in the northern part of GRKO, which contains easements for sewer lines and sewage lagoons owned and maintained by the City of Deer Lodge; (2) a scenic easement on adjacent ranch lands to maintain the visual integrity at the ranch's northern boundary; and (3) a transportation subzone for the Burlington Northern/Montana Western railroad right-of-way.

1.2 Ranch Operations

1.2.1 Historic

The following information regarding ranch operations is presented verbatim from the GRKO *Statement for Management* (1995).

> The first documented settler on the Grant-Kohrs Ranch site was John Francis Grant, whose fur trade upbringing led to trade with emigrants on the Oregon Trail at Fort Hall, Idaho. This led into the acquisition of livestock, which evolved into ranching. He established the ranch in 1862. In 1866 Grant sold the ranch and its assets to Carsten Conrad Kohrs. Kohrs and his half-brother, John Bielenberg, made it the operations base of a range cattle empire extending, by the 1890s, over several states, with land holdings of about 30,000 acres in the Deer Lodge Valley alone. He also owned nearly 1 million acres (in fee and by water rights) and grazed more than 10 million acres of public land, mainly in eastern Montana. Kohrs and Bielenberg, the Pioneer Cattle Company, were instrumental in upgrading the quality of range cattle, with the introduction of Shorthorn and Hereford bloodlines into the herds. Even the catastrophic losses of stock, which hit the industry in the unusually severe winter of 1886–1887, represented only a minor setback to their operation. Kohrs became prominent in the cattle industry and participated in territorial and state politics. In 1868 Conrad Kohrs married Augusta Kruse. After Conrad and Augusta Kohrs moved to Helena, Montana, in 1899–1900, Bielenberg continued ranching operations at Deer Lodge, but with homesteading encroaching on the open range and their fortunes made and secure, the partnership began winding down operations. When the two men died (Kohrs in 1920 and Bielenberg in 1922), Augusta Kohrs cared for the 1,000 or so remaining acres of the home ranch, which was officially operated and controlled by a corporation, the Kohrs Company. Augusta died in 1945.
>
> In 1932, Kohrs' grandson, Conrad Kohrs Warren, was employed as a foreman, and a new phase of expansion began. In 1934 Warren moved into the house, east of the railroad tracks, which had been a wedding gift to him and his wife, Nell Warren, from Augusta Kohrs. He bought the holdings of the Kohrs Company in 1940, and the ranch became known for its registered Hereford cattle and Belgian horses. In 1952, Warren moved the operations east of the railroad tracks to the upper bench of the ranch. The registered Herefords were dispersed in 1958, but ranching continued under Warren's direction with a commercial herd, even after purchase by the National Park Foundation in 1970. In 1980, Warren began leasing his remaining lands to local ranchers, until the 1988 purchase by the NPS. It was Warren and his wife who recognized the importance of the site, and through their efforts, it was preserved intact. When the NPS purchased the acreage and buildings at the center of the property from the National Park Foundation in 1972, they acquired a site changed only slightly from its origins as the headquarters for an open-range ranching operation.

1.2.2 Current

The purpose of GRKO is to preserve the historic integrity of the site, interpret the national values associated with the frontier cattle era, and provide for the benefit and inspiration of present and future generations (GRKO 1993). The ranch is a day-use site where visitors can take self-guided or guided tours. Summer activities include observing blacksmithing, chuck wagon cooking, and examples of 1890s cowboy life. GRKO receives approximately 20,000 visitors each year. Major attractions at GRKO are viewing the historic ranch house and ranch outbuildings, walking the nature trails, and observing cattle, horses, poultry and historic haying operations against a natural vista little changed in the past century. A prominent feature of GRKO's cultural landscape, and a significant reason for the establishment of ranch operations in this location beginning in 1859, is the Clark Fork River riparian corridor that today traverses the ranch for 3.5 river miles within the legislative boundary (2.44 miles under NPS management).

1.2.3 Summary of Previous Investigations

More than 25 previous investigations and studies have been undertaken to assess site conditions, including the evaluation of hazardous substance releases, identification of natural resource injuries, and the quantification of associated damages at GRKO. Table 1-1 lists the significant previous investigations and studies used to develop this document.

The NPS evaluated the Final Draft Feasibility Study (FS) (AERL 2002), Proposed Plan (EPA 2002), and ROD (EPA 2004a) to aid the development of this Plan. These documents provided a structured means to identify, develop, evaluate, and select remedial alternatives for the CFROU to eliminate, prevent, reduce, or control human health and/or environmental risks identified during the Remedial Investigation for the CFROU and otherwise comply with CERCLA, including compliance with "Applicable or Relevant and Appropriate Requirements" (ARARs).

The *Natural Resource Injury Report on Riparian and Upland Areas of Grant-Kohrs Ranch National Historic Site, Clark Fork River Basin, Montana* (Injury Report, EP&T 2002c) provided the determination and quantification of injury and damages upon which this Plan is based.[1] The Injury Report documented the magnitude of injury to natural resources at GRKO due to contamination from upstream mining activities. The Injury Report concluded that contaminant concentrations at GRKO are well above background concentrations and are sufficiently high to cause injury to natural resources. Injured soils result in direct toxicity to plants, restricted development of plant roots, loss of ecological functions mediated by microbes, loss of primary plant production, deviation of plant community composition, degradation of habitat, and alteration of the cultural landscape. The existing conditions and extent of natural resource injuries are described in Section 2 below.

[1] The Injury Report is available at the following web site: nps.gov/GRKO/naturalresourcemanagement/Superfund/Injury Report

2. EXISTING CONDITIONS

The climate and weather, geology, surface water, hydrogeology, vegetation, grazing practices, and natural resource injuries at GRKO are summarized below.

2.1 Climate and Weather

The climate along the Clark Fork River valley and GRKO is generally semi-arid. The ranch is sheltered from the worst effects of stormy weather by the surrounding mountains. The temperature is 90 degrees Fahrenheit (°F) or warmer an average of 9 days a year. The growing season (frost-free days) averages 95 days a year. On average, there are 21 days per year with maximum temperatures of 32°F or less. Annual precipitation averages 10.6 inches, with most of this falling in the form of rain during late spring and early summer. Winds are typically from the south or southwest and average about 5 to 7 miles per hour. River flow rates in the spring are determined by the amount of snowfall in the surrounding mountains and the rate at which it melts. The length of time between rainstorms can influence the amount of river water needed for irrigation purposes and can also influence the fate and transport of contaminants in soil (Schafer & Associates 1998).

2.2 Geology

Between the headwaters of the Clark Fork River and the northern end of the Deer Lodge Valley, the Clark Fork River basin is composed mainly of unconsolidated gravel, sand, silt, and clayey alluvium eroded from surrounding highlands and deposited in alluvial fans. Sediments in this area can be as thick as 5,000 feet (ft). Between Warm Springs Ponds and Deer Lodge, the river flows mainly north, but turns to the northwest between Deer Lodge and Garrison, following the trend of the underlying geology. Deposits of alluvium are generally thinner in this reach (less than 200 ft); the river down-cuts through exposed Cretaceous or Paleozoic sedimentary rocks. Beyond Bearmouth, the river flows mainly over older Precambrian and Proterozoic rock (Schafer & Associates 1998).

2.3 Surface Water

The upper Clark Fork River drains an area of approximately 3,650 square miles. Major tributaries to the Clark Fork River include Silver Bow Creek, Warm Springs Creek, Little Blackfoot River, Flint Creek, Rock Creek, and Blackfoot River. GRKO is located on the Clark Fork River between Warm Springs Creek and Little Blackfoot River. Flow rates in the Clark Fork River are highly variable depending on location and time of year. Average flows are around 250 to 300 cubic feet per second (cfs) at the headwaters and increase (because of the influx from tributaries) to around 2,000 cfs near the town of Milltown, Montana. Peak flow rates typically occur in late May or early June, and low flow usually occurs in the fall and winter. Most floods occur in the spring as the result of snowmelt, but winter and summer floods can also occur following major rainstorms. Under low flow conditions, the Clark Fork River is a gaining stream (groundwater discharges into the river) over most of its length. Water from the river is withdrawn at numerous points to irrigate agricultural land, most of which is used to grow hay for livestock.

The Clark Fork River serves multiple purposes, including stock water, irrigation, recreation, and aquatic habitat. The State of Montana has assigned use classifications for different segments of the Clark Fork River based on water quality conditions and surface water use goals. The first segment, from the headwaters to Cottonwood Creek at Deer Lodge, is classified as C-2. The C-2 classification indicates that the river is suitable for bathing, swimming, and recreation; growth and marginal propagation of salmonid fishes, aquatic life, waterfowl, and mammals; and agricultural and industrial water supply. The second segment lies between Cottonwood Creek to the Little Blackfoot River and is classified as C-1, which includes all of the same uses as C-2 except for full (rather than marginal) propagation of salmonid fishes and aquatic life. GRKO lies in this segment of the river. The third segment of the Clark Fork River, from the confluence with the Little Blackfoot River to the former Milltown Dam site, is classified as B-1, which includes all of the uses associated with the C-1 classification as well as drinking and culinary uses after conventional treatment. A small segment of the stream, from the confluence of the old Silver Bow Creek channel with the reconstructed bypass to the confluence with Warm Springs Creek, is also classified as B-1 (EPA 2001).

2.4 Hydrogeology

The principal source of groundwater used by humans living and ranching in the CFROU is an unconfined aquifer located in the unconsolidated and semi-consolidated alluvium. Depth to groundwater varies from near surface to more than 150 ft below ground surface. Groundwater flow generally follows surface water flow and topography. Locally, groundwater flows out of highland areas toward the river; regionally, it flows north-northwest down the river valley (EPA 2001).

Locally, groundwater at GRKO occurs near the surface at variable depths generally correlated to the proximity to the Clark Fork River. The water table is within about 5 ft or less of the land surface within the floodplain area, increasing to 10 to 20 ft below land surface under the gravel terraces to the east, and is 30 ft or more below the surface in the upper parts of the west side fields (Woessner and Johnson 2002). In general, Woessner and Johnson (2002) show that groundwater in the water table aquifer flows toward the Clark Fork River, where groundwater discharges to surface water flow in the river, flowing northwesterly toward the river on the east side of the river and northeasterly toward the river on the west side of the river.

The State of Montana has classified the groundwater in and near the ranch as potentially usable as drinking water. According to GRKO documents, multiple types of wells exist on GRKO: groundwater monitoring, domestic, irrigation, and stock (GRKO 1993). Currently the drinking water supply for humans and the majority of cattle at the ranch is not drawn from the ranch's groundwater resources, but obtained from the City of Deer Lodge's water supply system. One groundwater supply well is used infrequently for livestock watering (Foster Wheeler 2003a). In addition, numerous recent studies have been performed to characterize water resources at GRKO (Moore and Woessner 2001; Woessner and Johnson 2002). As part of these studies, a number of groundwater monitoring wells have been installed to characterize and monitor the groundwater quality and determine the hydrogeologic characteristics of the groundwater system.

2.5 Vegetation

A detailed vegetation study by Rice and Hardin (2002) concluded that there is a diverse riparian corridor at GRKO as well as irrigated fields and upland pastures. Within the riparian corridor, 23 plant communities were identified, including seral stage community types, grazing disclimaxes, and climax habitat types (Figure 2-1). Areas devoid of vegetation because of high metal concentrations or sparsely vegetated with metals-tolerant plants species (i.e., tufted hairgrass) were designated as slickens. Slickens covered approximately 8 acres of the GRKO floodplain (Figure 2-2) (EP&T 2002c). The dominant plant communities are water birch, geyer willow, smooth brome, and geyer willow/beaked sedge (Table 2-1) (Rice and Hardin 2002). Additional discussion on the effects of the chemicals of concern (COCs) on vegetation is presented in the Injury Report.

2.6 Grazing Practices

GRKO has been the headquarters for cattle ranching operations for more than 125 years. The mission of the park is to preserve and interpret the frontier cattle era of the nation's history, beginning in the 1860s. The majority of the ranch property has been used for forage and hay production and for livestock grazing. According to GRKO records, the fenced riparian corridor of GRKO was not a principal grazing area, but was used for winter calving. Because the land holdings were so extensive (including a 30,000 acre home ranch and grazing across approximately 10 million acres under the management of Conrad Kohrs and John Bielenberg), cattle were grazed at disparate locations. Cattle have been explicitly excluded from grazing in the 127-acre fenced riparian corridor since spring 1994. Cattle are currently rotated through upland and irrigated pastures. Hay is produced in the irrigated fields.

2.7 Natural Resource Injuries

NPS undertook a series of comprehensive studies to identify and quantify the natural resource injuries at GRKO, focusing on injuries to soils of the riparian areas and historically irrigated fields. The NPS injury assessment was multifaceted and included quantitative studies of contaminant levels in various affected media, as well as the collection of data related to other physical, chemical, and biological parameters that directly or indirectly measured injuries to the natural resources at GRKO. NPS conducted the following activities:

- Sampled and analyzed surface and subsurface soils, sediment, surface water, groundwater, soil pore water, and vegetation for COCs
- Measured physical and chemical parameters in the soil, the groundwater aquifer, and biological resources and collected data on the characteristics of the geologic, hydrologic, and geomorphological systems
- Collected and analyzed data on the riparian areas, various biological species, and other ecological systems at the park
- Collected and analyzed data on the baseline conditions that would be expected to exist at the park but for the presence of COCs

The major findings of the data collection and analysis effort were summarized and published in numerous individual reports on the various media or resources (Table 1-1). The results of those resource-specific reports were further compiled, evaluated, and synthesized in the Injury Report (EP&T 2002c). The following section is a synopsis of that report.

A major concern at GRKO is that soil has been injured, as defined in 43 C.F.R. 11.62(e), due to the release of hazardous substances associated with large-scale mining activities in the areas of Butte and Anaconda, Montana. Mining and smelting in these areas began in 1864 and continued until the closure of the Washoe Smelter near Anaconda in 1980 and the cessation of upstream mining activities in 1983. Contaminant sources include historical discharges of raw, untreated mining and mineral-processing wastes into Silver Bow Creek and Warm Springs Creek, smelting waste deposits and aerial deposition, waste rock deposits, and tailings deposits. Due to the vast quantity of mining-related waste now present in the Clark Fork River floodplain, hazardous substance releases are ongoing through the process of erosion, sedimentation, precipitation, and so on. The major COCs detected in soils, groundwater, surface water, and plant tissues at GRKO are arsenic, cadmium, copper, lead, and zinc.

According to the Injury Report, exposure to hazardous substances resulted in direct toxicity to plants, loss of critical ecological functions mediated by microbes, loss of primary production, deviation of plant community composition from that expected for the area, and restricted development of plant root systems. Specifically, the Injury Report concluded the following:

- Growth and survival of herbaceous and woody species in controlled laboratory tests decreased as COC levels increased.
- Root growth was among the most sensitive endpoints in all species tested.
- Above-ground herbaceous plant growth measured in field clip plots decreased as pH-adjusted arsenic, copper, and zinc levels increased.
- Patterns of plant cover on a small-scale differed in relation to levels of COCs. Known metals-tolerant species (e.g., tufted hairgrass, redtop bentgrass, booth willow, etc.) were more prominent as pH-adjusted arsenic, copper, and zinc levels increased.
- The riparian plant community structure on a macro-scale deviated from expected baseline conditions in 63 percent of GRKO riparian areas.
- The patterns of soil respiration differed in relation to concentrations of COCs, as did patterns of microbial community structure.

Furthermore, the presence of hazardous substances was determined to have long-lasting negative consequences on critical ecological functions carried out by soil microbes, resulting in the following:

- Loss of agricultural/livestock production potential
- Loss of recovery potential should other disturbances, such as fire or drought, occur
- Disruption or alteration of elemental cycles such as those exhibited by carbon and nitrogen
- Land degradation, such as soil erosion, with subsequent sediment deposition and desertification

A key conclusion of the Injury Report was that the concentrations of COCs at GRKO are well above background concentrations and are sufficiently high to have caused phytotoxic responses in several plant species, thereby causing injury to natural resources. The area of injured soil is approximately 122 acres of the 127-acre fenced riparian corridor (Figure 2-3), including approximately 8 acres of barren and tufted hairgrass slickens. As further discussed in the Injury Report, despite extensive data collection at GRKO, the spatial heterogeneity of contaminant distribution is such that an exact footprint of the areal extent of injured soils has not been drawn; to do so would require a concentration of geochemical data on a grid of less than 5 meter increments throughout GRKO. Such a sampling effort was deemed prohibitively costly. Data are sufficient, however, to prepare probabilistic plots that can be used to predict the likelihood of encountering injured soil at any particular location and depth (Figures 2-4 and 2-5). As shown in Figure 2-4, there is a 90-percent probability of encountering phytotoxic soil within the first 3 ft of the soil profile at any given location within the sampled area. In addition, there is a 90-percent probability of encountering soil horizons toxic to microbes in the first 3.5 ft of the soil profile, as shown in Figure 2-5.

For the purposes of this report, the 127-acre fenced riparian corridor is shown on many of the figures for reference. Figure 2-3 shows the 127-acre fenced riparian corridor that includes the 122 acres of injured soils identified in the Injury Report. The areas mapped in the Injury Report as slickens are depicted in Figure 2-2. Details of the extent of injured soils and the degree of impact to soils and other natural resources relative to baseline conditions are presented in Section 4, as is information on design criteria and assumptions for restoring injured natural resources to baseline conditions.

3. REMEDIATION SUMMARY

This Plan assumes that remedial action will be implemented as described in the ROD (USEPA, April 2004). The subsections below present a summary of anticipated activities for site-specific implementation of the remedy at GRKO.

3.1 Summary of Selected Remedy for CFROU

As described by the ROD, the Clark Fork River Riparian Evaluation System (RipES) will be used as an evaluation tool to identify the remedial action appropriate to a given site in the riparian buffer zone, floodplain, and historically irrigated fields. The RipES system identifies vegetation polygons on the ground through field observations and analytical testing. The polygons are divided into six categories—three classes of stream banks within the riparian buffer zone and three types of soils within the historical floodplain. Under remedial action, the three RipES-defined soil type categories in the floodplain are:

1. Slickens and exposed tailings—These areas will require removal of phytotoxic soil, replacement with clean soil where necessary to provide adequate clean growth medium and floodplain stability, and revegetation with native plant communities.

2. Impacted soils and vegetation areas—These areas will predominantly receive in situ treatment of phytotoxic soil, except in circumstances requiring selected removals where tailings and/or impacted soils extend below 2 ft or are too wet to treat in situ. Such locations include old oxbow channels and wetlands. At these locations, the phytotoxic soils will be removed and replaced. Treatment or removal will be followed by revegetation with native plant communities. Impacted soils and vegetation areas within GRKO at which in situ treatment failed to attain location-specific ARARs, or at which the determination is made to remove rather than treat impacted soils, will be revegetated with native plant communities following removal.

3. Slightly impacted soils and vegetation areas—These areas are characterized by relatively healthy mature woody vegetation that generally will be left undisturbed despite elevated COC concentrations in underlying soils.

Under the selected remedy, RipES places all stream banks into one of three categories ranging from least to most stable. The three stream bank classes are:

- Class 1—Contaminated, unvegetated, and actively eroding areas without deep, binding, woody vegetation. These areas would require removal of phytotoxic material, soft engineering treatments, and revegetation.

- Class 2—Contaminated, partially vegetated, and unstable and eroding areas that would respond to supplemental revegetation with bioengineering techniques. Reconfiguration of stream banks may be required.

- Class 3—Contaminated, but stable, vegetated areas where best management practices (BMPs) would meet remedial action objectives (RAOs).

3.2 Summary of Remedy Implementation at GRKO

Implementation of the remedial action at GRKO is expected to result in the removal from approximately 8 acres of slickens of an estimated 38,720 cubic yards (cu yds) of contaminated soil to an average depth of 3.0 ft. Excavated areas will be backfilled to consist of an estimated thickness of 9 to 12 inches of clean cover soil and a total uncontaminated rooting medium 18 inches deep (EPA 2004a; p. 2–113) for native plant community revegetation and to promote geomorphic stability.

Phytostabilization (i.e., in situ treatment) will be applied to 33 acres of impacted soils. While it is anticipated that in situ treatment will result in the successful re-establishment of woody vegetation, uncertainty remains due to the paucity of relevant data. Given this uncertainty, the ROD allows for up to three replanting attempts following in situ treatment; in the event location-specific ARARs are not attained after these attempts, removal of contaminated soils will be required. Consequently, the possibility exists that removal of impacted soils, using the soil removal techniques applied in the slickens areas, will be required to achieve the performance standards. This second phase of remedial action would result in the removal of an additional 159,720 cu yds of soil. The extent and timing of removal of impacted soils, if it is deemed necessary to meet the requirements of the ROD, will be determined by NPS, USEPA, and the State of Montana during remedial action at GRKO.

Fifty-three acres of slightly impacted soils within the floodplain will be left untreated to preserve existing woody vegetation and floodplain stability. As noted in the ROD (page 2-108), however, this area is not considered to be uninjured.

Riverbanks along 2.44 miles of the Clark Fork River will be stabilized with soft engineering techniques and plantings of herbaceous and shrubby vegetation. A 50-ft wide riparian buffer zone (RBZ) will be replanted (approximately 28 acres) to reduce bank erosion and the lateral transport of metals contamination to the river.

The 41 acres in the floodplain outside of the RBZ where slickens were removed (8 acres) and impacted soils treated or removed (33 acres) will be revegetated according to the plant community structure in the ROD to meet the performance criteria of the location-specific ARARs.

All excavated areas will be backfilled with cover soils to provide a suitable planting medium. The cover soils will be of sufficient thickness to achieve a minimum of 18 inches of hospitable root zone of nontoxic rooting media according to the ROD Section 13.8.2.1 (EPA 2004a). Final topography in excavated areas will be determined based on the optimum soil and hydrologic conditions needed within a given polygon for the plant community or communities desired in that area.

Arsenic-contaminated soil in the ditches and ditch berms will be addressed only where it exceeds the EPA action level of 620 mg/kg for the rancher/farmer population. Based on the current geochemical data, no additional soil removal in the ditches is expected using this arsenic action level.

Other components of the remedial action include development and implementation of plans for weed management and grazing management, as well as utilization of best management practices during Site work.

4. RESTORATION DESIGN AND IMPLEMENTATION

NPS has evaluated the residual injury to natural resources anticipated to remain after implementation of the remedial action. This evaluation is based primarily on information presented in the Injury Report (EP&T 2002c), FS (AERL 2002), Proposed Plan (EPA 2002), Ditch Report (Moore 2003), ROD (EPA 2004a), and input from NPS and DOI staff.

Injured soils result in direct toxicity to plants, loss of ecological functions associated with and mediated by microbial activity, loss of primary plant production, deviation from the expected plant community composition, degradation of habitat, alteration of the cultural landscape, restricted development of plant roots, and accelerated stream bank erosion. These natural resource injuries are documented to have occurred on at least 122 acres at GRKO. Natural resource injury is further quantified in the following:

- Slickens (described as soils with surficial tailings that are devoid of vegetation, with the margins supporting tufted hairgrass) comprise approximately 8 acres in GRKO floodplain and riparian corridor (Figure 2-2). The average depth of contamination in the CFROU slickens was 3.0 ft deep as determined by site-specific studies and summarized in the Injury Report.

- Approximately 114 acres of injured non-slickens floodplain soils. Figure 2-3 shows the 127-acre fenced area in the floodplain at GRKO that encompasses the floodplain and riparian corridors and contains the total 122 acres of injured soils (8 acres of slickens and 114 acres of non-slickens).

- There is a 90-percent probability of capturing phytotoxic soils with effective treatment or removal of injured soils to a depth of 3 ft (90 centimeters) (Figure 2-4).

- There is a 90-percent probability of capturing contaminated soils that inhibit soil microbial respiration with effective treatment or removal of injured soils to a depth of 3.5 ft (105 centimeters) (Figure 2-5).

Residual injury is expected after implementation of the selected remedy and, absent restoration measures, will prolong the rate of natural resource recovery, fail to achieve the restoration objectives, and increase the long term costs of ranch management for NPS. The restoration measures discussed below are intended to address residual injuries in a manner that complements, and can be implemented simultaneously with, the remedial action. Consistent with the CFROU Consent Decree and Superfund Memorandum of Agreement (SMOA), restoration measures will be implemented by the State of Montana under NPS oversight and subject to NPS review and approval.

4.1 Regulatory Framework

The U.S. Department of the Interior (DOI) is authorized to take appropriate actions necessary to protect and restore natural resources and the services provided by those resources, where such resources are injured by a release or substantial threat of release of hazardous substances. The following laws and regulations, *inter alia*, apply to restoration efforts and provide DOI with the legal authority to fulfill its responsibilities as a natural resource trustee:

- CERCLA, as amended (42 U.S.C. §§ 9601 to 9675), including but not limited to Sections 104, 107, 111(i), and 122
- Oil Pollution Act of 1990 (33 U.S.C. §§ 2701 to 2761), including but not limited to Sections 1006 and 1012
- Federal Water Pollution Control Act (or "Clean Water Act"), as amended (33 U.S.C. §§ 1251 to 1387), including but not limited to Section 311(f)
- National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. Part 300 *et seq.*
- Natural Resource Damage Assessment (NRDA) Regulations for CERCLA, 43 C.F.R. Part 11
- National Park Service Organic Act, 16 U.S.C. §§ 1-4
- General Authorities Act, 16 U.S.C. §§ 1a-1 to 1c

4.2 Restoration Goals

The restoration goals applicable to injured natural resources at GRKO are as follows:

- Re-establish the diverse, self-perpetuating baseline plant community conditions of the GRKO riparian area as it was in the mid-1860s, prior to the commencement of large-scale mining activities upstream
- Promote an ecologically stable riparian corridor along the Clark Fork River at GRKO
- Remove any contaminant-related constraints upon the injured areas to allow for full and unrestricted use of ranch resources for all park purposes, including interpretive, educational, and operational activities

4.3 Restoration measures

4.3.1 Stream Bank Stabilization

One component of injury determination at GRKO involved assessment of stream bank conditions and associated stabilization needs. Bank stabilization and erosion control techniques were conceptually designed using the *Integrated Stream Bank Protection Guidelines* (WSAHGP 2002), hydraulic parameters obtained from the Haestad Methods FlowMaster (FlowMaster) hydraulic modeling program (see Appendix A for hydraulic calculations), shear stress calculations (Appendix B), and various vegetative stabilization techniques, among other considerations. Figures 6-1, 6-2, and 6-3 illustrate features along the river corridor and show the stationing along the river centerline. Hydraulic parameters, shear stress, and scour depth were calculated (see Appendices A and B). NPS considered vegetation, pre-vegetated coir fiber rolls, biodegradable soil matting, and other stabilization methods as possible techniques to address soil erosion along the stream banks of GRKO. Calculations for erosion control are presented in Table 6-4.

This information will be factored into the remedial design process and a determination made as to the extent to which remedial action will address these stabilization needs. Those components of bank stabilization not captured under remedial action will be identified and performed as restoration. Potential restoration measures include utilization of additional tipped willows and prevegetated coir fiber rolls, in combination with other robust revegetation techniques.

4.3.2 Monitoring

Site-specific studies at GRKO indicate that elevated COC concentrations and visible tailings are present from the surface to the depth of groundwater (which varies from 3 to 5 feet in the GRKO floodplain). Residual contamination will remain in large areas of the GRKO floodplain after remedial action, particularly in the 53 acre slightly impacted area noted in the ROD (page 2-110). Considerable uncertainty exists as to the effectiveness of revegetation efforts if COCs remain in the subsoils. This is particularly true of woody species the root systems of which must penetrate the zones of residual contamination. To account for seasonal fluctuations in precipitation, current drought conditions, and the slower growth rate of woody species, GRKO restoration extends monitoring an additional 5 years beyond that required by the ROD, to a total of 15 years. The purpose of this extended monitoring period is to ascertain whether additional restoration actions are necessary to accelerate the rate of resource recover or to better realize the restoration objectives.

4.3.3 Re-establishment and Augmentation of Plant Community Diversity

Baseline plant communities are those that would have occurred in the absence of phytotoxic contaminant concentrations. By comparing the baseline to the existing conditions, the magnitude of resource injury can be quantified. Table 6-1 and Figure 6-4 present the baseline plant communities existing at GRKO in 2000. Rice (2003) identified 17 probable baseline plant communities encompassing 50.8 acres, or 40.1 percent of the riparian floodplain. Augmentation of species diversity and planting density will be a restoration measure implemented in conjunction with remedial action to ensure the realization of the baseline plant community mosaic in the GRKO floodplain.

Restoration measures will enhance the species mix within the 28-acre RBZ as well. Restoration measures will include, inter alia, planting a combination of willow cuttings, stakes, bags, prevegetated fiber coir rolls, and live transplants of shrubby and herbaceous species (to the extent that such measures are not required as part of remedial action). In addition to these planting and transplanting methods, mature willow transplants will be salvaged on-site, then anchored and tipped over the banks to deflect and reduce water flows immediately adjacent to the banks. Overall, revegetation would be directed to achieve the baseline plant community composition in the RBZ according to the restoration objectives. Augmentation planting may be applied in other areas if needed to achieve a more rapid recovery to baseline.

4.3.4 Phytotoxic Soil Removal along Irrigation Ditches

Indications of phytotoxicity have been noted in numerous locations along the historically irrigated ditches, particularly on the berms of Kohrs Ditch west of the Clark Fork River. GRKO restoration removes these phytotoxic materials and replaces the berms to eliminate further restrictions on the management and operation of these ditches as part of the historic landscape of the ranch. Removal of phytotoxic berm soils is estimated to be an additional 6,240 cu yds of material to be hauled to Opportunity Ponds for disposal (Table 6-3). Areas of excavation would be reconstructed with clean soil and revegetated to re-establish ditch stability and productivity, allowing the NPS to achieve full, unencumbered use of the irrigation ditches with historic practices and methods.

4.3.5 Supplemental Activities

- Remove test plot exclosures installed as part of damage assessment.
- Rehabilitate tensiometers, peizometers, and ground water monitoring wells as part of an expanded monitoring program.

- Provide for NPS oversight of restoration plan development and implementation, ensuring appropriate and efficient integration with remedial action consistent with the Consent Decree and the SMOA.

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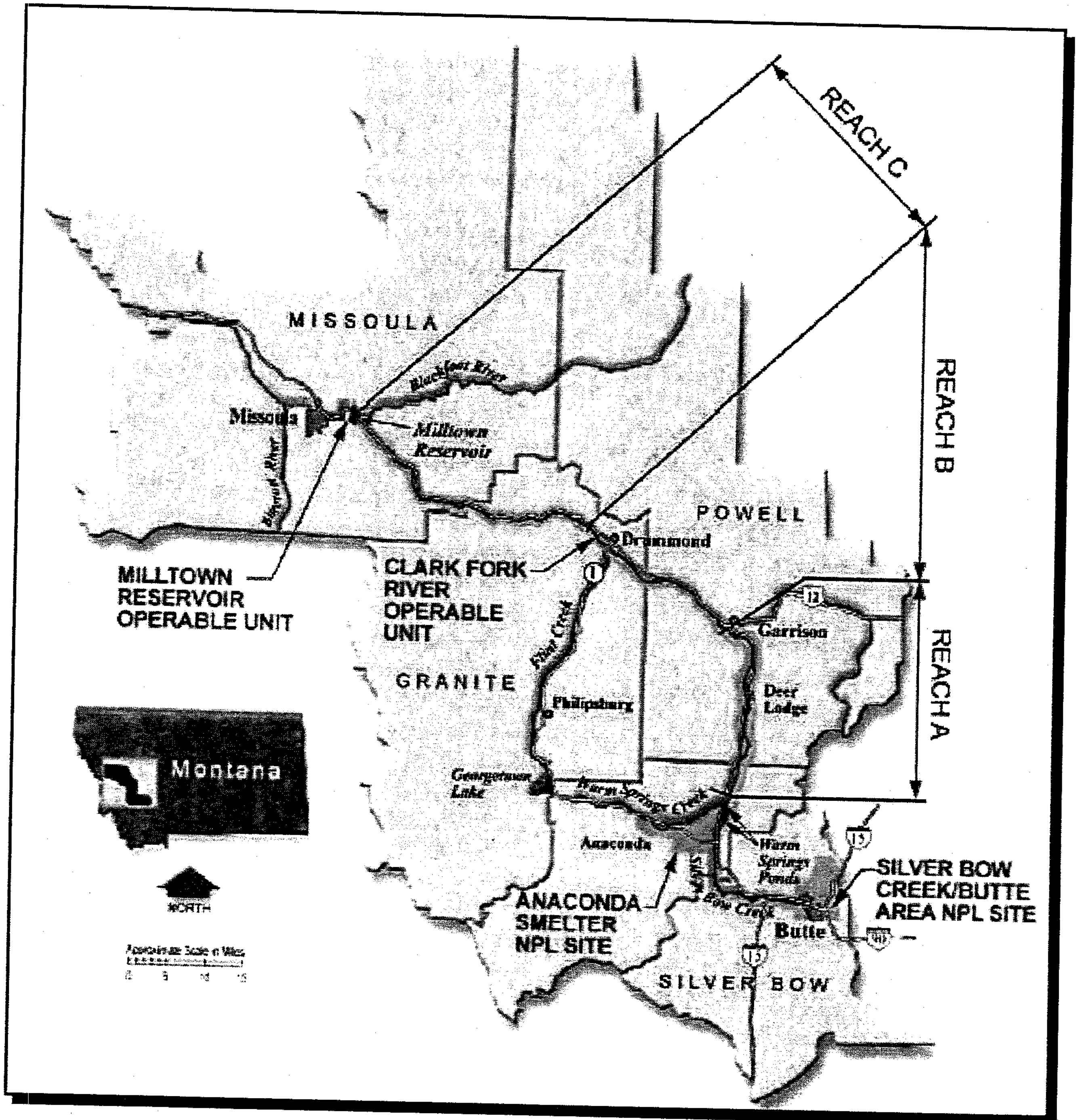
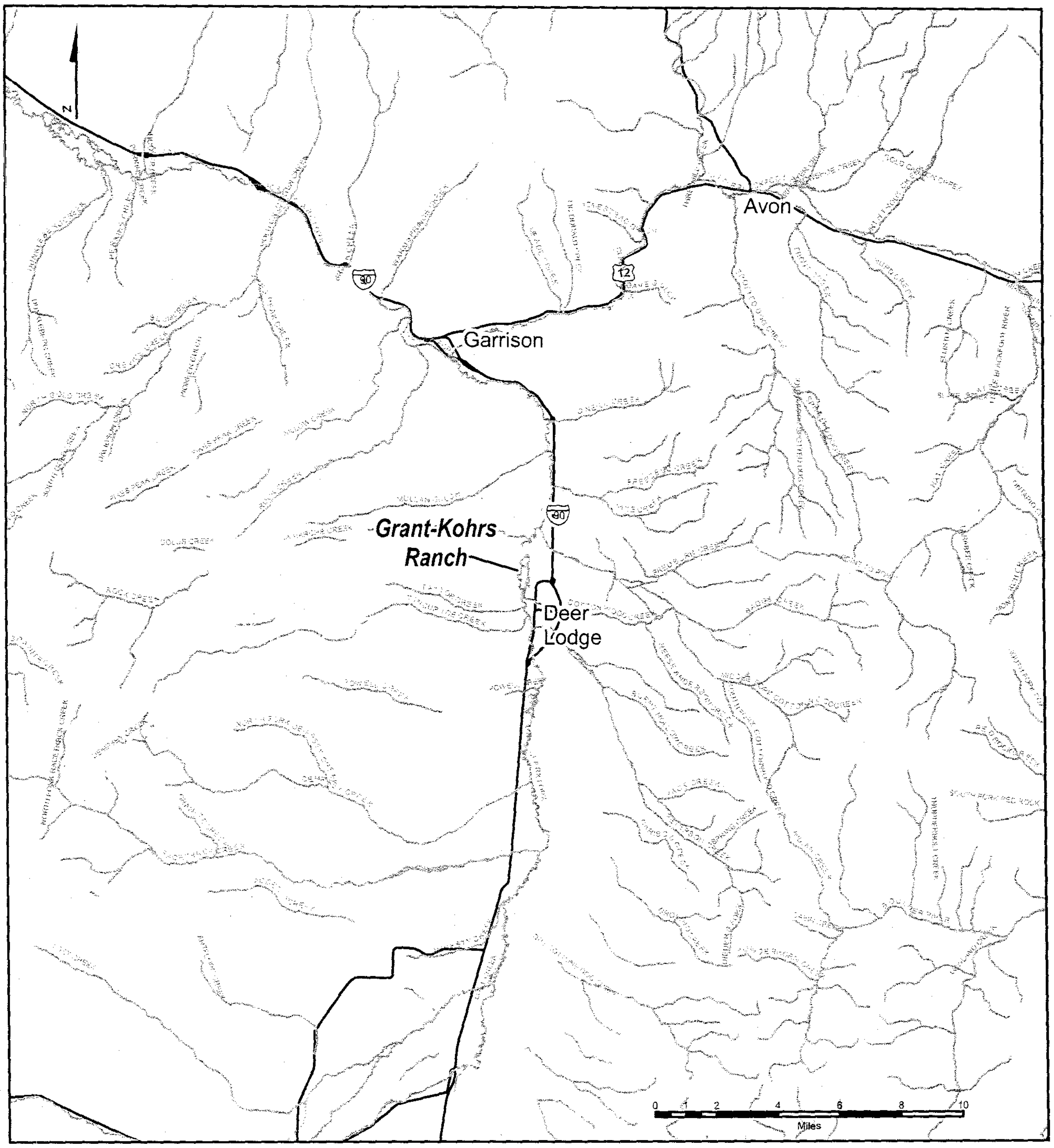
FIGURES

Figure 1-1 Vicinity Map



Source: EPA (2004)



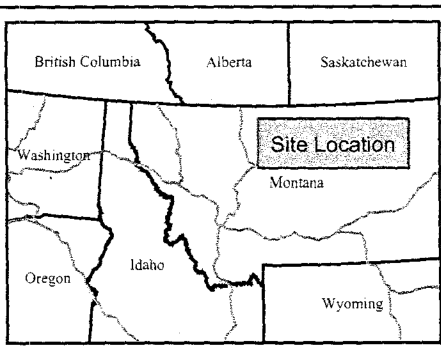


Figure 1-2
Site Location Map

Grant-Kohrs Ranch
National Historic Site

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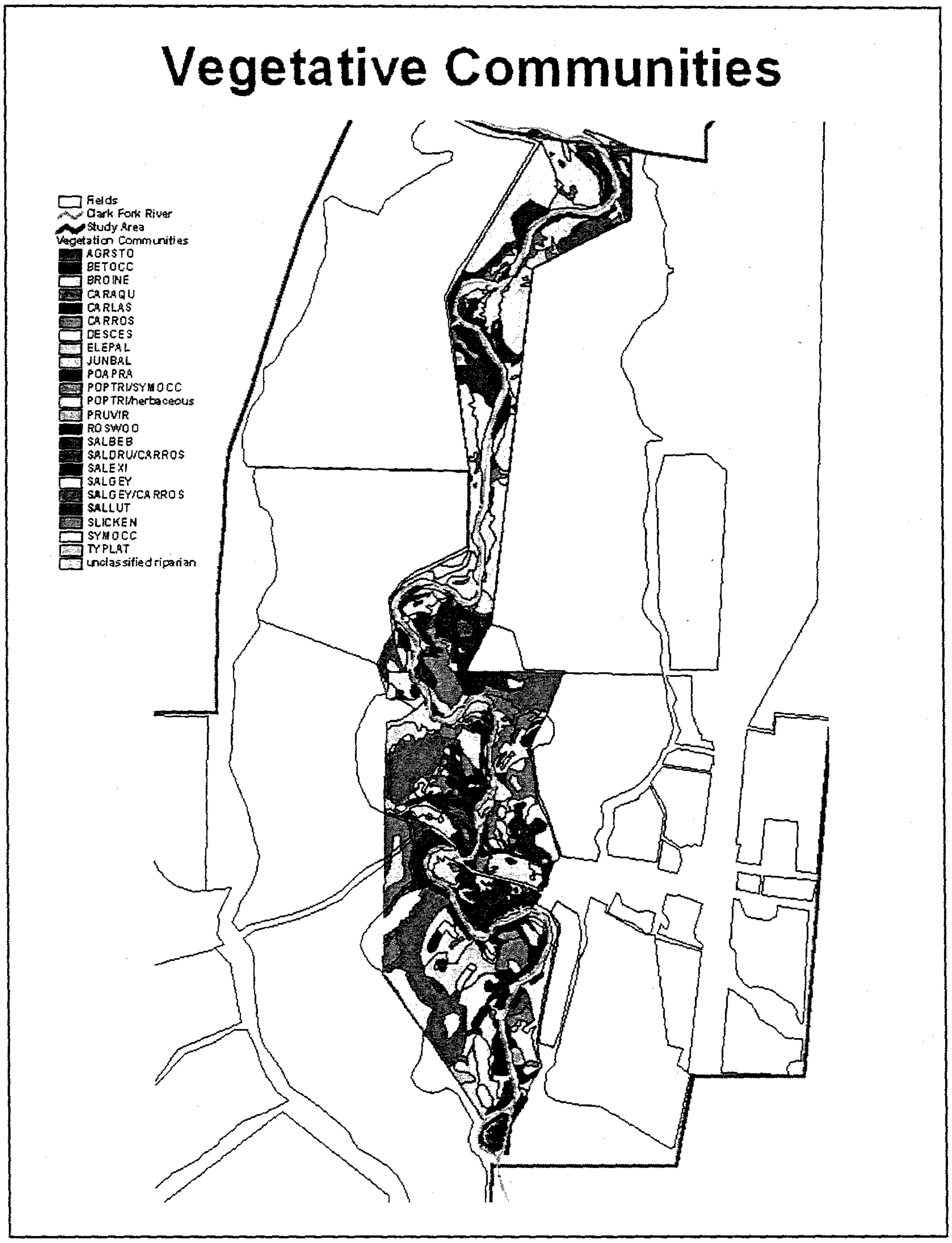


Figure 2-1. Existing Vegetative Communities

Source: EP&T 2002b.

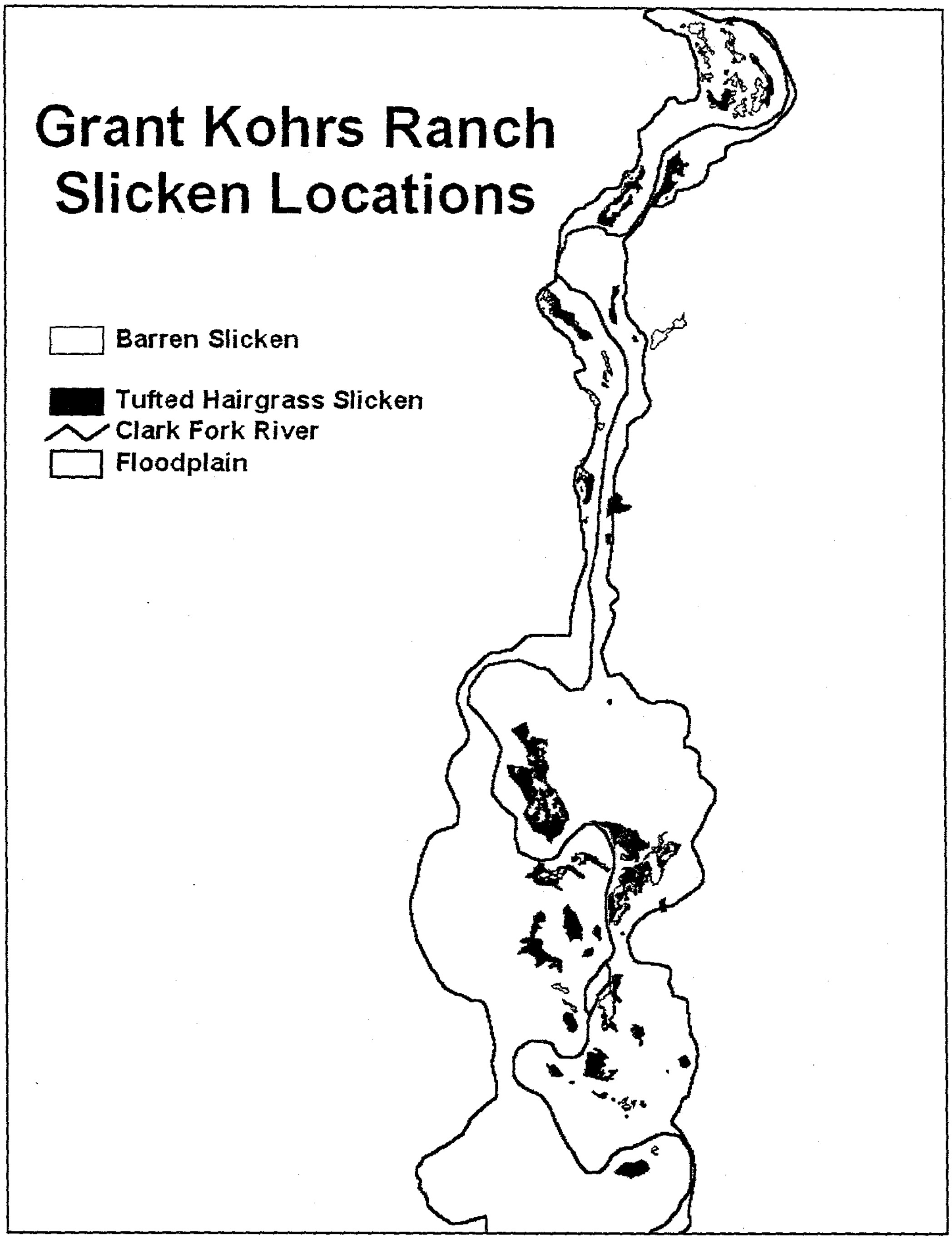


Figure 2-2. Slickens Locations

Source: EP&T 2002b.

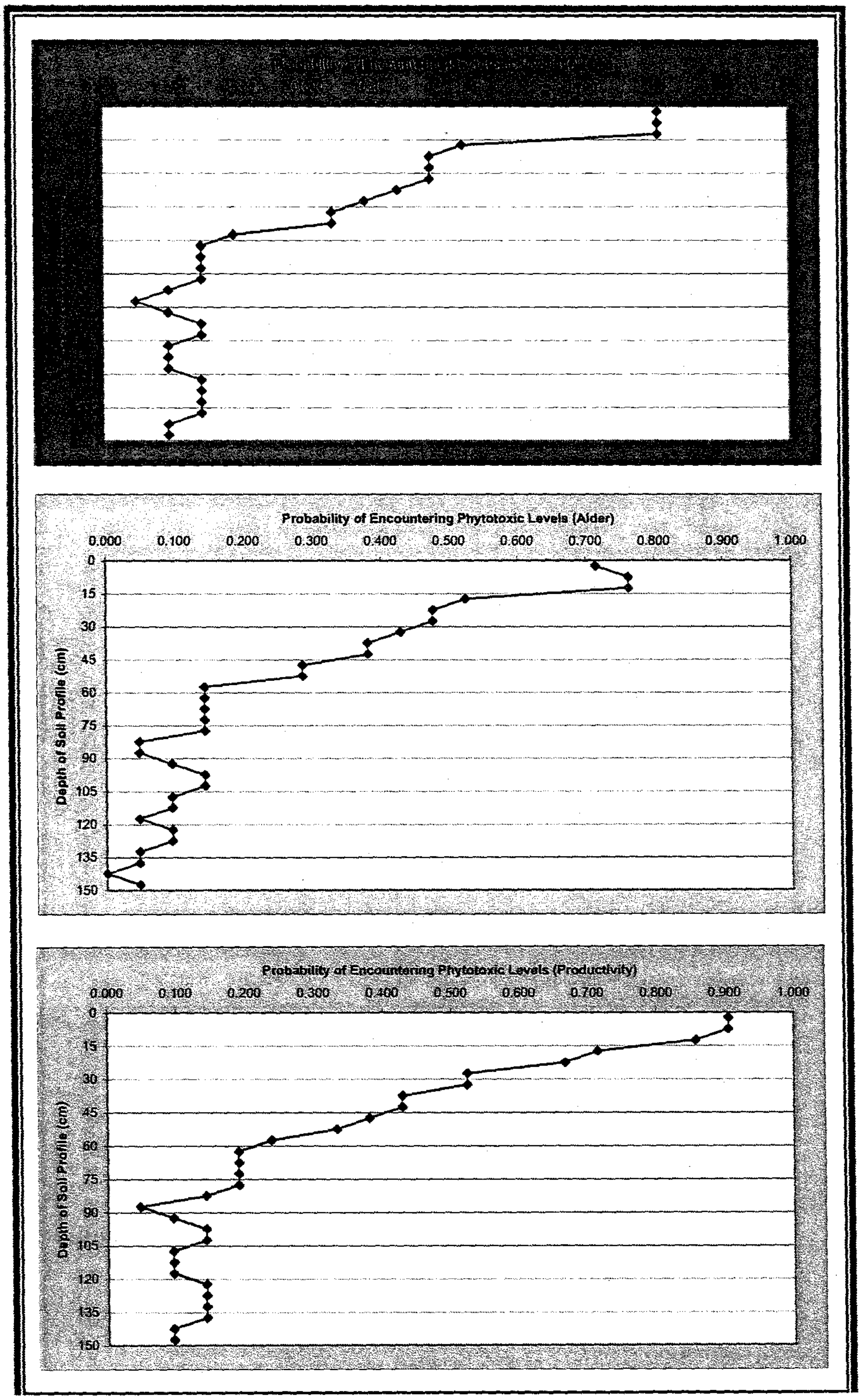


Figure 2-4. Probability of Encountering Phytotoxic Soils

Source: EP&T 2002b.

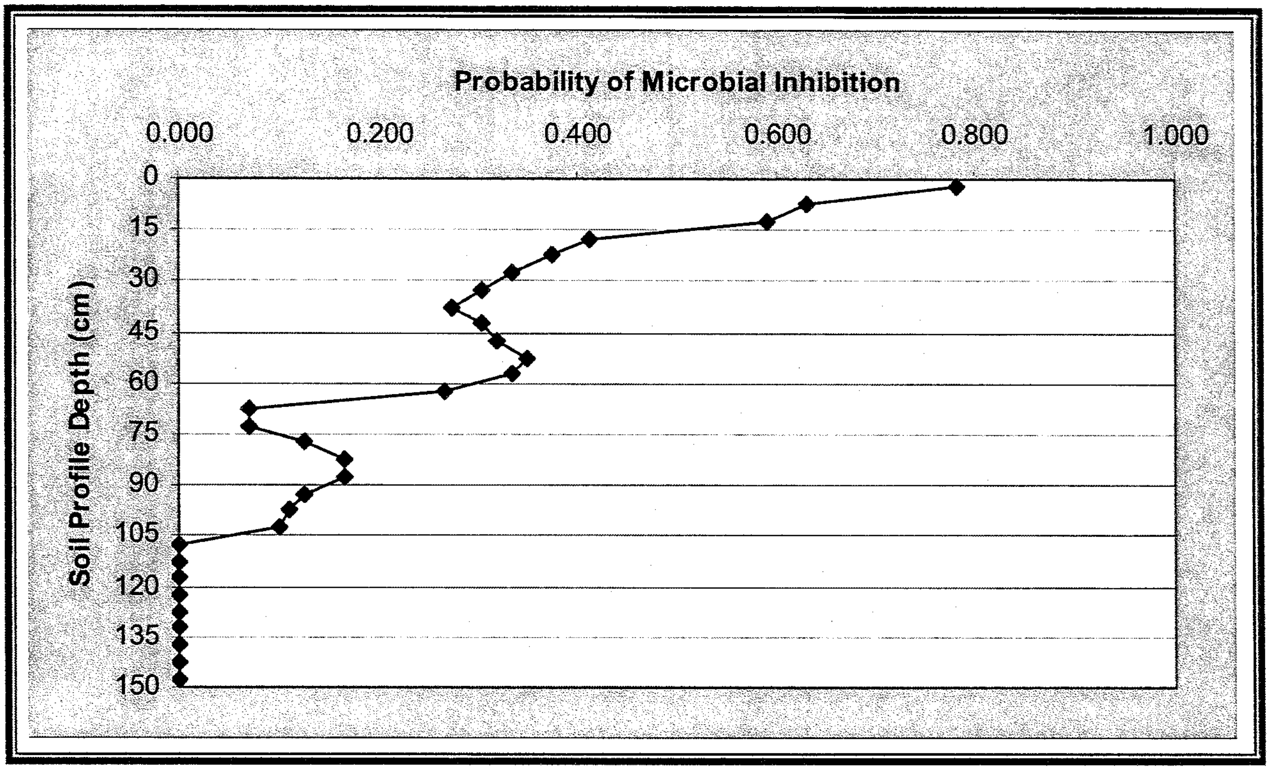
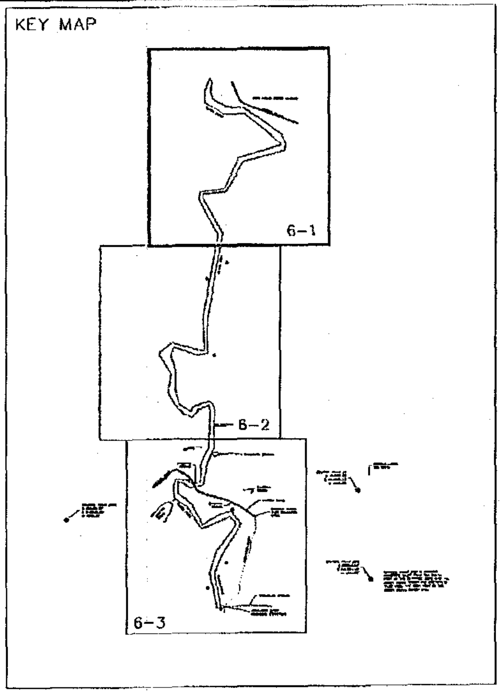
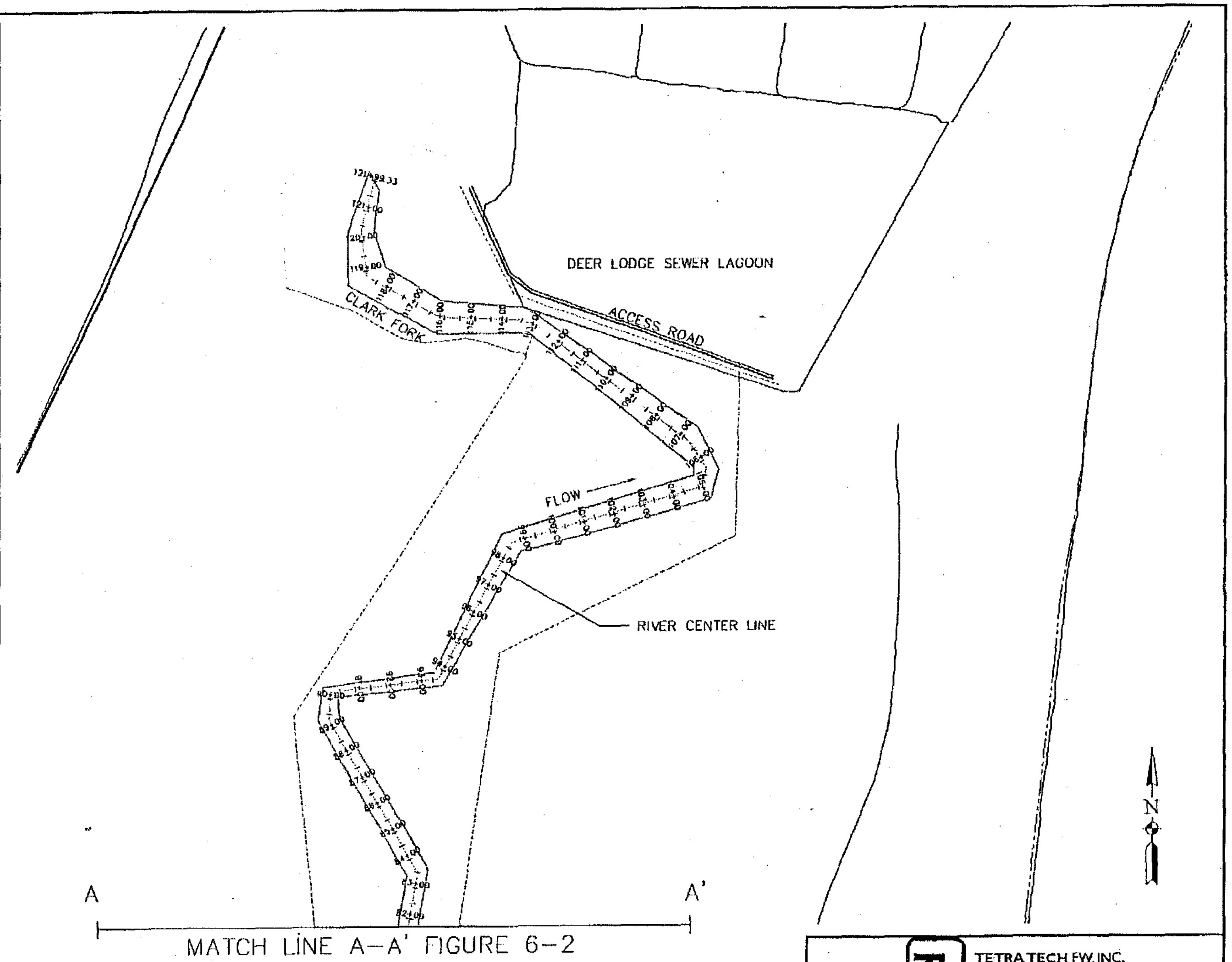


Figure 2-5. Probability of Encountering Soils Toxic to Microbes

Source: EP&T 2002b.





LEGEND:

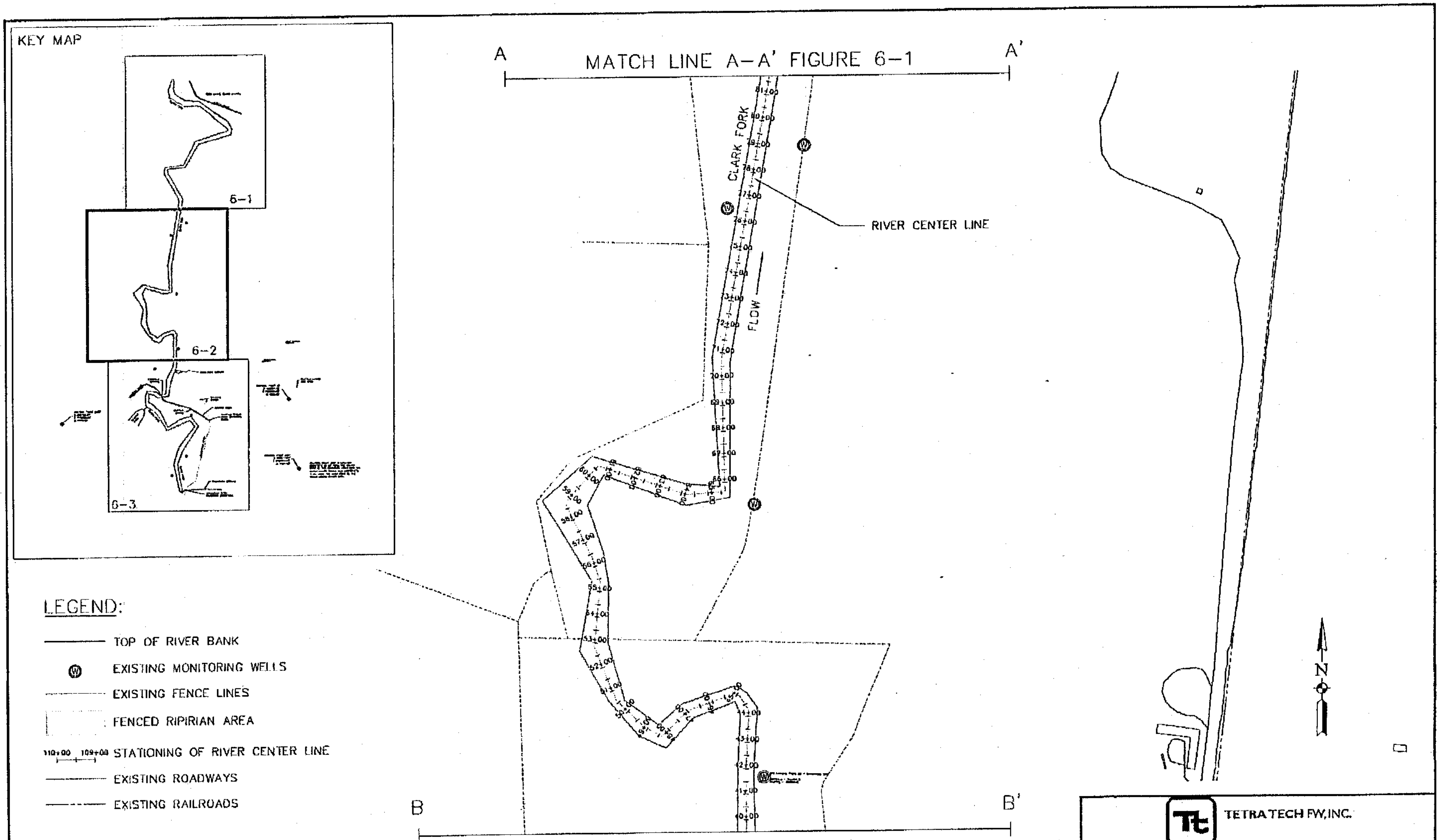
- TOP OF RIVER BANK
- EXISTING FENCE LINES
- FENCED RIPIRIAN AREA
- 110+00 108+00 STATIONING OF RIVER CENTER LINE
- PROJECT BOUNDARY
- EXISTING ROADWAYS
- EXISTING RAILROADS

NOTE:
1. REFER TO DETAIL FIGURES 6-5 THROUGH 6-8 FOR DIMENSIONS AND EROSION CONTROL/STABILIZATION MEASURES

175 87.5 0 175 350 525
SCALE IN FEET

TETRA TECH FW, INC.

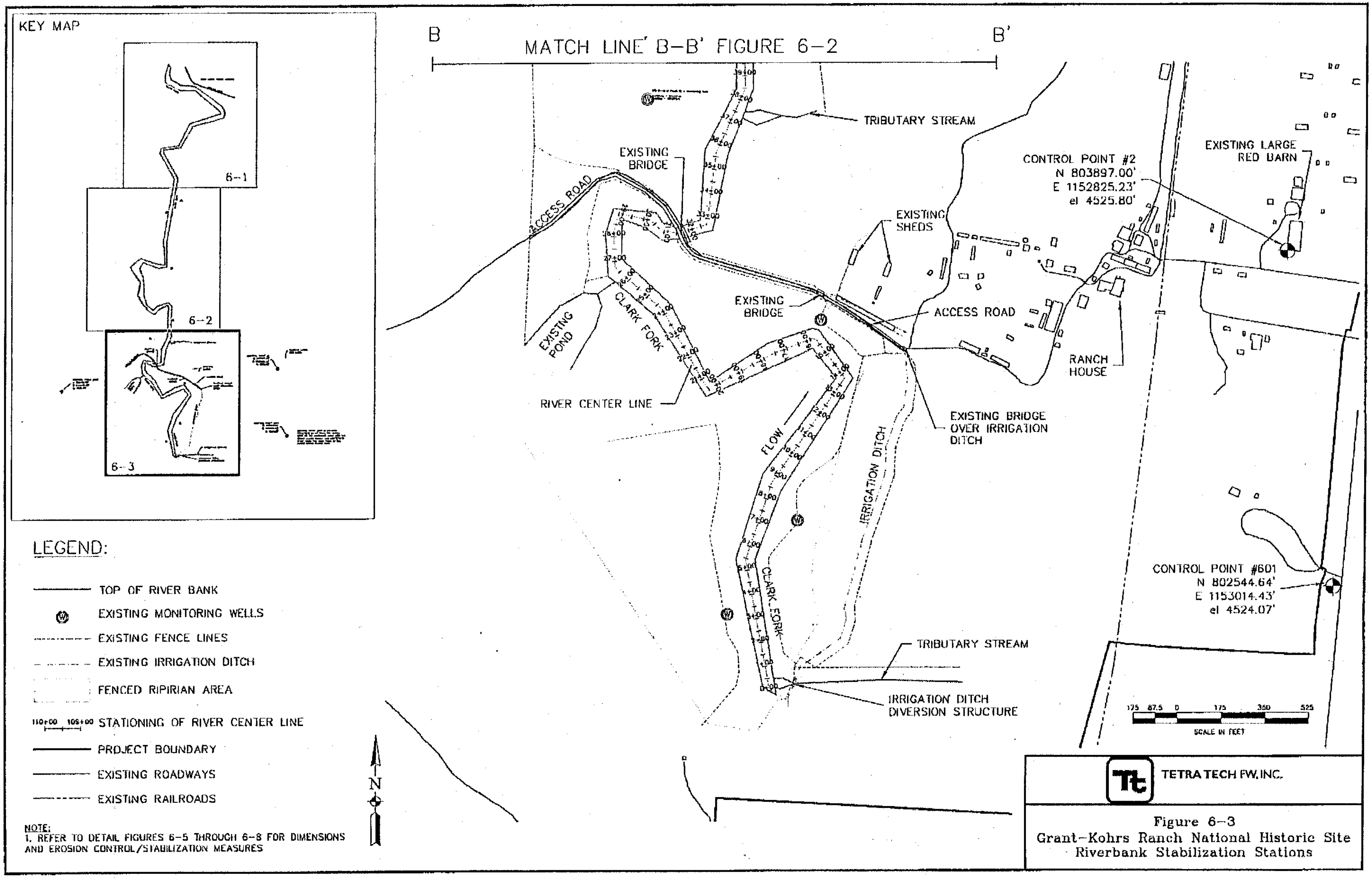
Figure 6-1
Grant-Kohrs Ranch National Historic Site
Riverbank Stabilization Stations



NOTE:
1. REFER TO DETAIL FIGURES 6-5 THROUGH 6-8 FOR DIMENSIONS AND EROSION CONTROL/STABILIZATION MEASURES !

TETRA TECH FW, INC.

Figure 6-2
Grant-Kohrs Ranch National Historic Site
Riverbank Stabilization Stations



LEGEND:

- TOP OF RIVER BANK
- EXISTING MONITORING WELLS
- EXISTING FENCE LINES
- EXISTING IRRIGATION DITCH
- FENCED RIPIRIAN AREA
- 110+00 105+00 STATIONING OF RIVER CENTER LINE
- PROJECT BOUNDARY
- EXISTING ROADWAYS
- EXISTING RAILROADS

NOTE:
1. REFER TO DETAIL FIGURES 6-5 THROUGH 6-8 FOR DIMENSIONS AND EROSION CONTROL/STABILIZATION MEASURES

TETRA TECH FW, INC.

Figure 6-3
Grant-Kohrs Ranch National Historic Site
Riverbank Stabilization Stations

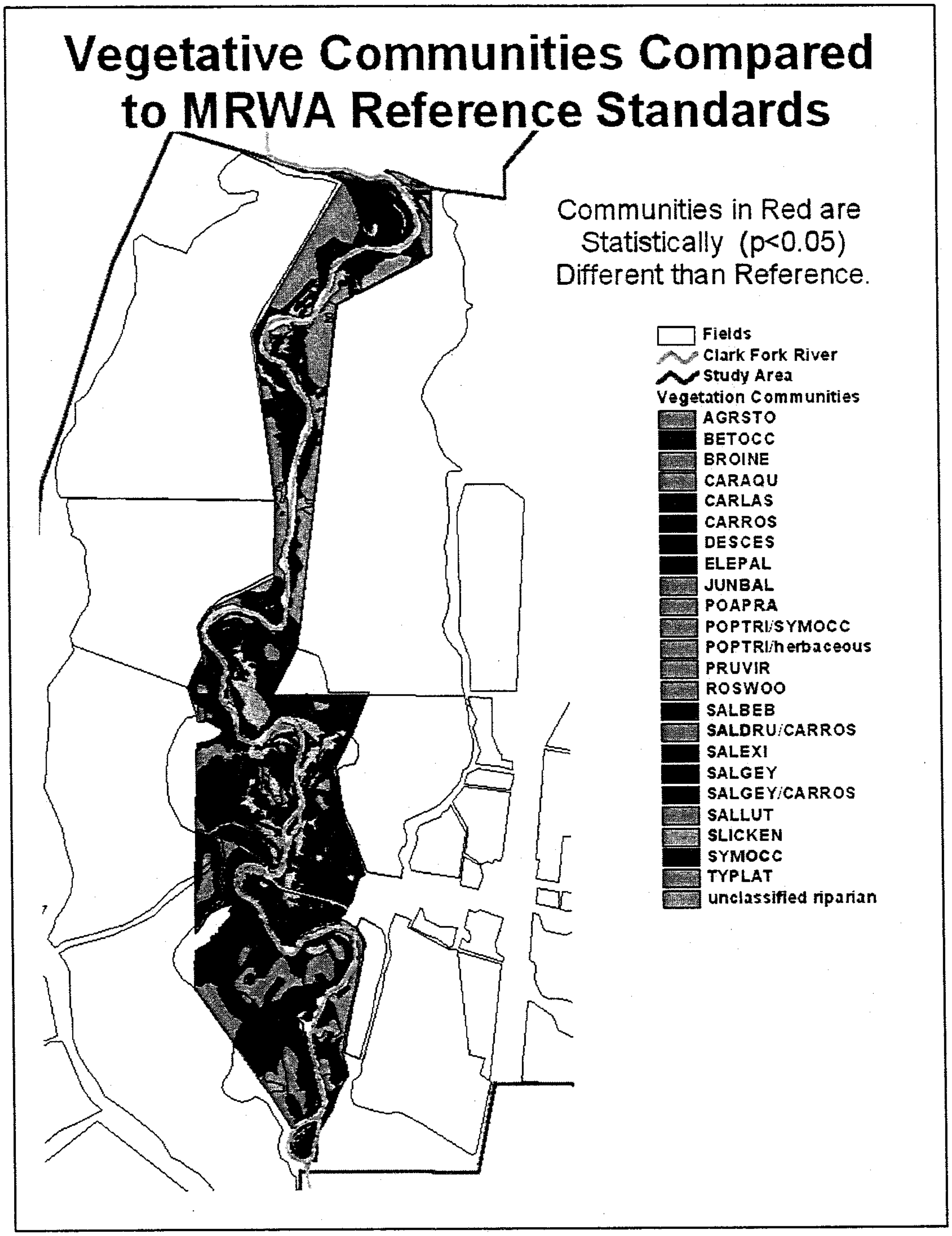
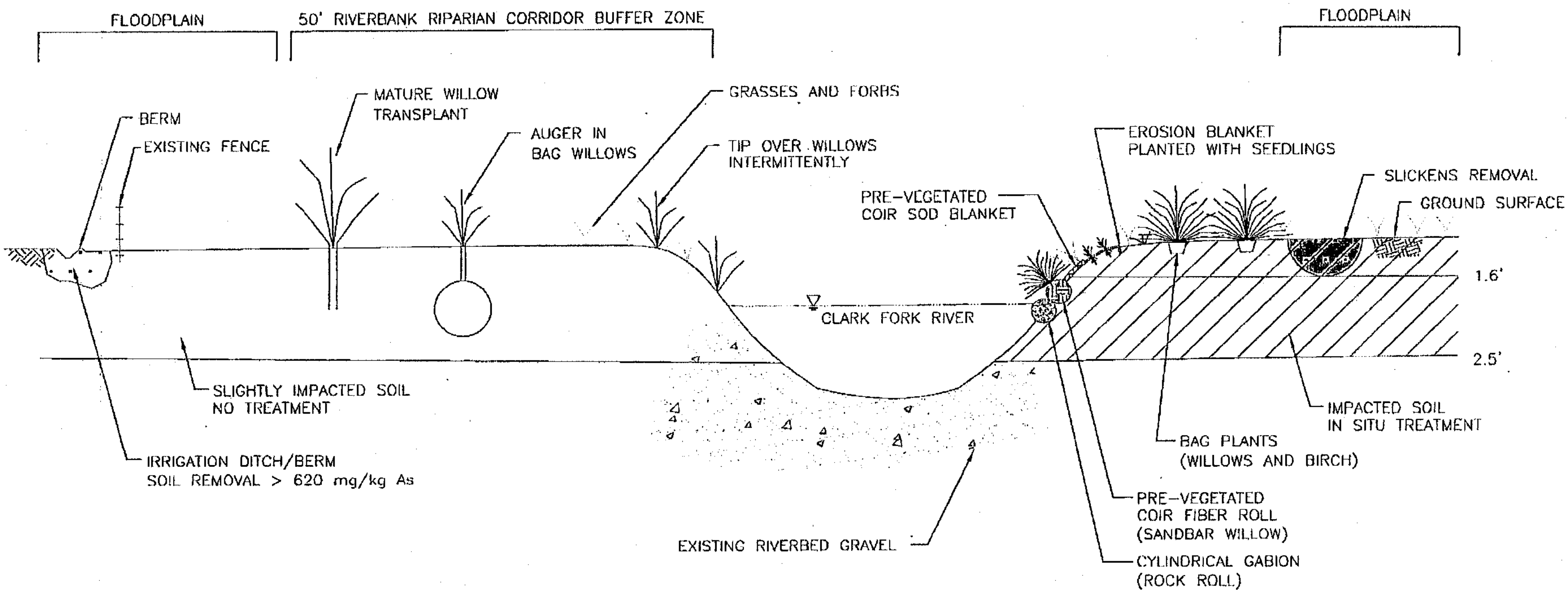


FIGURE 6-4. EXISTING VEGETATIVE COMMUNITIES COMPARED TO MONTANA RIPARIAN AND WETLAND ASSOCIATION (MWRA) REFERENCE TYPES

Source: EP&T 2002b.



NOTES:

1. RESTORATION WILL OCCUR ALONG A MINIMUM OF 9,450 FEET OF CUT BANKS ON THE RIVER, WITHIN THE FENCED RIPARIAN CORRIDOR AREA. SEE FIGURE 2-3.
2. BASELINE VEGETATION COMMUNITIES WILL EXTEND FROM 50' RIVERBANK RIPARIAN CORRIDOR BUFFER ZONE TO THE FENCED RIPARIAN AREA. SEE FIGURE 2-3.
3. EXCAVATED AREAS WILL BE BACKFILLED WITH CLEAN SOIL WHERE NEEDED FOR FLOODPLAIN STABILITY AND FOR PLANT ROOTING MEDIA.
4. EXISTING VEGETATION IN THE SLIGHTLY IMPACTED AREA WILL BE UNALTERED IN THE FLOODPLAIN.
5. TREATMENT MAY VARY WITH REGARD TO STREAM CLASSIFICATION.

LEGEND:

∇ — SURFACE WATER LEVEL

NOT TO SCALE

TETRA TECH FW, INC.

Figure 6-5
Grant-Kohrs Ranch National Historic Site
Riverbank Stabilization

TABLES

Table 1-1. Previous Investigations and Studies of the GRKO

Report	Author	Content
Geologic, Soil Water and Groundwater Report 2000, Grant-Kohrs Ranch National Historic Site. February 2001.	J. N. Moore and W. Woessner	Determination of the nature and extent of contamination and pathways of contaminant migration at GRKO.
Final Phytotoxicity Tests on Soils from the Grant-Kohrs Ranch National Historic Site, Deer Lodge, Montana. January 2002.	Ecological Planning and Toxicology, Inc.	Describes phytotoxicity test results from studies in fall 2000 through summer 2001.
Geochemistry and Fluvial Geomorphology Report—A Draft Report to the Grant-Kohrs Ranch National Historic Site. January 2002.	J. N. Moore, B. Swanson, and C. Wheeler	Determination of geochemistry of multi-parameter sampling plots and description of fluvial geomorphology of the Clark Fork River at GRKO.
Toxic Metals-pH Impact on Riparian Plant Community Structure at Grant-Kohrs Ranch. February 2002.	P. M. Rice	Describes the impacts that releases of hazardous substances have had on riparian plant communities at GRKO.
Rice, Peter M. and Janet Hardin, 2002. Riparian Plant Community Structure at Grant-Kohrs Ranch. March 2002.	P. M. Rice and J. Hardin	Describes the plant communities in the floodplain and riparian zone at GRKO.
Baseline Vegetation Types for Grant-Kohrs Ranch National Historic Site. July 2003.	P. M. Rice	Describes the mosaic of plant communities that would exist in the GRKO floodplain were it not for releases of hazardous substances.
Chemical Concentrations in Surface Soils of the Irrigation Ditch Berms, Grant-Kohrs Ranch National Historic Park. May 2003.	J. N. Moore	Reports the levels of metals detected in soil samples from berms along irrigation ditches at GRKO.
Public Review Draft Feasibility Study Report, Milltown Reservoir Sediments NPL Site, Clark Fork River Operable Unit. March 2002.	ARCO Environmental Remediation, L.L.C.	Identifies, develops, and evaluates remedial alternatives to eliminate, prevent, reduce, or control human health and/or environmental risks identified during the Remedial Investigation for the CFROU.
Relationship of Heavy Metal Contamination to Soil Respiration. March 2002.	J. E. Gannon and M. Rillig	Discusses soil microbial respiration and microbial community and plant toxicity studies throughout the GRKO riparian zone in summer 2001.
Bank Erosion and Metal Loading in a Contaminated Floodplain System Upper Clark Fork River Valley, Montana. 2002.	B. J. Swanson	Unpublished master's thesis that describes the geomorphology of the CFR in GRKO and historical patterns of erosion and deposition
Natural Resource Injury Report on Riparian and Upland Areas of the United States Department of Interior Within the Clark Fork River Basin, Montana. May 2002.	Ecological Planning and Toxicology, Inc.	This report synthesizes the data reports related to site characterization and natural resource damage assessment and determines injury to natural resources at GRKO.
Superfund Program Clean-Up Proposal, Clark Fork River Operable Unit of Milltown Reservoir/Clark Fork River Superfund Site. August 2002.	U.S. Environmental Protection Agency	Presents the proposed cleanup action along the Upper Clark Fork River.
Record of Decision, Clark Fork River Operable Unit of Milltown Reservoir Sediments/Clark Fork River Superfund Site. April 2004.	U.S. Environmental Protection Agency	Presents the Selected Remedy for the CFROU, including the GRKO area, and summarizes the process that was used to select it.

Table 2-1. Plant Communities of the GRKO

5.1.1.1 Plant Community[1]	Plant Community Common Name	Number of GRKO Polygons	Total Acres	Percent Riparian
Community Type (Seral Stage):				
BETOCC	Water Birch	50	17.6	14.0
SALEXI	Sandbar Willow	39	9.7	7.7
SYMOCC	Snowberry	18	3.3	2.6
PRUVIR	Chokecherry	1	0.3	0.2
		108	**30.8**	**24.5**
Grazing Disclimax:				
SALGEY	Geyer Willow	70	28.3	22.4
BROINE	Smooth Brome	18	17.0	13.5
JUNBAL	Baltic Rush	20	5.6	4.5
AGRSTO	Redtop Bentgrass	20	4.3	3.4
SALBEB	Bebb Willow	9	2.0	1.6
POPTRI/SYMOCC	Cottonwood/Snowberry	2	1.5	1.2
ROSWOO	Woods Rose	10	1.2	1.0
POAPRA	Kentucky Bluegrass	1	0.2	0.2
POPTRI/HERBACEOUS	Cottonwood/Herbaceous	1	0.2	0.1
SALLUT	Yellow Willow	2	0.1	0.1
		153	**60.4**	**47.9**
Habitat Type (Climax):				
SALGEY/CARROS	Geyer Willow/Beaked Sedge	5	13.8	10.9
CARROS	Beaked Sedge	12	3.3	2.4
CARLAS	Slender Sedge	9	1.0	0.8
DESCES	Tufted Hairgrass	8	0.6	0.5
TYPLAT	Cattail	4	0.5	0.4
CARAQU	Water Sedge	2	0.5	0.4
ELEPAL	Spikesedge	3	0.1	0.1
SALDRU/CARROS	Drummond Willow/Beaked Sedge	1	0.1	0.1
		44	**19.7**	**15.6**
Other:				
Slickens	Slickens	37	7.9	6.3
Unclassified Riparian	Unclassified Riparian	20	7.2	5.7
		57	**15.1**	**12.0**

1 Source: Rice and Hardin (2002).

Table 6-1. Baseline Plant Communities Occurring at GRKO in 2000

Plant Community Common Name	Type Class	Number of Native Taxa (> = 1% CC)	5.2 Year 2000 Status		
			Number of Polygons	Total Acres	Riparian (%)
Water Birch	CT	25	50	17.6	14.0
Geyer Willow/Beaked Sedge	HT	25	5	13.8	10.9
Sandbar Willow	CT	12	39	9.7	7.7
Snowberry	CT	16	18	3.3	2.6
Beaked Sedge	HT	12	12	3.3	2.4
Slender Sedge	HT	20	9	1.0	0.8
Tufted Hairgrass	HT	20	8	0.6	0.5
Cattail	HT	5	4	0.5	0.4
Water Sedge	HT	11	2	0.5	0.4
Chokecherry	CT	22	1	0.3	0.2
Spikesedge	HT	14	3	0.1	0.1
Drummond Willow/Beaked Sedge	HT	25	1	0.1	0.1
Geyer Willow/Bluejoint Reedgrass	HT	35	0	0	0
Yellow Willow/Bluejoint Reedgrass	HT	24	0	0	0
Yellow Willow/Beaked Sedge	HT	30	0	0	0
Bluejoint Reedgrass	HT	19	0	0	0
B. Cottonwood/Red-Osier Dogwood	CT	30	0	0	0

CC = Canopy cover
CT = Community type (seral stage)
HT = Habitat type (climax)

Source: Rice 2003

Table 6-2. Comparison of Remedy and Restoration

<table>
<tr><th rowspan="2">Activity</th><th rowspan="2">Riparian Buffer Zone
(28 Acres)</th><th colspan="3">Within The Floodplain
(94 Acres)</th><th rowspan="2">Other Activities</th></tr>
<tr><th>Slickens
(Exposed Tailings)
(8 Acres)</th><th>Moderately Impacted Soils and Vegetation Areas (33 Acres)</th><th>Slightly Impacted Soils and Vegetation Areas
(53 Acres)</th></tr>
<tr><td rowspan="2">Phase I Remedial Action
EPA Remedy – Slickens Removal and In Situ Treatment of Impacted Soils</td><td rowspan="2">Stabilize both riverbanks in 50-ft RBZ along 2.44 miles CFR using soft engineering. Replant a minimum of 14 acres of restored banks with combinations of willow plantings and herbaceous and shrubby transplants.</td><td>Removal of 8 acres of slickens to depth of 3.0 ft.</td><td>In situ treatment of impacted surface soils on 33 acres.</td><td rowspan="2">No Action on 53 acres of relatively mature woody vegetation.</td><td rowspan="2">• Ditch berms: remove soil >620 mg/kg As–EPA's action level for rancher/farmer
• Soil disposal at Opportunity Ponds
• Temporary erosion controls
• BMPs
• Long-term O & M
• Monitoring for 10 years</td></tr>
<tr><td colspan="2">Revegetate 41 acres with a mixture of species according to the planting criteria and plant community structure presented in the ROD.</td></tr>
<tr><td>Restoration
Augmentation of density and diversity of revegetation effort</td><td>Incorporate additional soft engineering techniques into bank stabilization effort.</td><td colspan="2">Augment plant species diversity in revegetation effort to maximize the achievement of the baseline plant community in excavated or treated soils.</td><td>Interplant baseline species on 53 acres of extant woody vegetation.</td><td>• Ditch berms: remove phytotoxic soil
• Removal of test plot exclosures
• Project management & oversight
• Monitoring for an additional 5 years</td></tr>
<tr><td>Phase II Remedial Action
EPA Remedy – Removal of Previously Treated Impacted Soils if Performance Criteria Not Met</td><td></td><td></td><td>Removal and revegetation of 33 acres of previously treated soils to a depth of 3.0 ft.</td><td></td><td>• Soil disposal at Opportunity Ponds
• Temporary erosion controls
• BMPs
• Long-term O & M
• Monitoring for 10 years</td></tr>
</table>

Table 6-3. Soil Volumes for Removal or Treatment

Activity	Area (acres)	Remedy Phase I (cu yd)	Restoration (cu yd)	Remedy Phase II (cu yd)
Earthwork Removal				
Irrigation Ditches and Berms		0	6,240	0
Slickens excavation - 3.0 ft	8	38,720	0	0
Excavation of phytotoxic soils after treatment attempt - 3 ft	33	0	0	159,720
Total Earthwork Removal	**41**	**38,720**	**6,240**	**159,720**
In Situ Treatment				
Impacted Soil – 3.0 ft	33	159,720	0	

cm = centimeter
cu yd =cubic yards
ft = feet

Table 6-4. Erosion Control Design

Segment Number	Associated Cross Section	Station (ft)	Channel Bottom Width (ft)	Design Sideslope (H:V)	Design Scour Depth (ft)
1	1	5+43	Varies	Varies	N/A
2	2	11+78	100	2:1	3
3	3	18+06	40	2:1	0
4	3A	19+63	Varies	Varies	N/A
5	4	21+80	50	2:1	3
6	5	26+73	80	2:1	1
7	6	29+96	40	2:1	5
8	7	34+33	40	2:2	2
9	8	37+05	65	2:1	3
10	9	40+42	105	2:1	6
11	10	43+37	Varies	Varies	N/A
12	11	46+12	25	2:1	1
13	11A	46+97	Varies	Varies	N/A
14	12	49+82	100	2:1	4
15	13	54+15	40	2:1	1
15	14	54+15	30	2:1	2
16	15	56+75	20	2:1	2
17	16	62+72	85	2:1	3
18	17	68+08	40	2:1	2
19	18	72+46	60	2:1	3
20	18A	82+17	Varies	Varies	N/A
21	19	84+70	75	2:1	2
22	19A	88+44	Varies	Varies	N/A
23	20	91+36	40	2:1	3
24	20A	92+90	Varies	Varies	N/A
25	21	94+39	55	2:1	7
26	21A	97+45	Varies	Varies	N/A
27	22	99+99	80	2:1	3
28	22A	104+11	Varies	Varies	N/A
29	23	106+50	80	2:1	3
30	23A	111+66	Varies	Varies	N/A
31	24	117+21	95	2:1	5
32	25	121+99	55	2:1	2

N/A indicates straight segments where only vegetative erosion control measure will be used
H:V horizontal to vertical

Hydraulic calculations were performed in FlowMaster assuming trapezoidal channel types for all cross sections, a 2:1 sideslope, 2,500 cubic feet per second storm flow, and a Manning Coefficient of 0.030. All other data from AutoCAD is calculated with the same methods used in Appendix B for the Pre-Construction Scour Depths.

Table 6-6. Erosion Control Design

Segment Number	Associated Cross Section	Station (ft)	Cross Section	Shear Stress in Bends > 2 (psf)[1]	Bend Radius > 3W	Visual Inspection for Engineered Stabilization Needs	5.3 Erosion Control Comments[2]
2	2	11+78	**2**	1.09	304		Vegetative/mat/roll erosion control sufficient
3	3	18+06	**3**	0.99	17	X[3]	Robust erosion control recommended
5	4	21+80	**4**	1.71	-105		Vegetative/mat/roll erosion control sufficient
6	5	26+73	**5**	0.78	97		Vegetative/mat/roll erosion control sufficient
7	6	29+96	**6**	3.45	-46	X[4]	Robust erosion control required, structural protection
8	7	34+33	**7**	2.82	13	X	Robust erosion control recommended
9	8	37+05	**8**	2.79	148		Robust erosion control NOT recommended[5]
10	9	40+42	**9**	1.63	-90		Vegetative/mat/roll erosion control sufficient
12	11	46+12	**11**	2.93	-3	X	Robust erosion control recommended
14	12	49+82	**12**	0.96	-218		Vegetative/mat/roll erosion control sufficient
15	13	54+15	**13**	1.49	-53		Vegetative/mat/roll erosion control sufficient
15	14	54+15	**14**	3.52	35		Robust erosion control NOT recommended[5]
16	15	56+75	**15**	3.70	47		Robust erosion control NOT recommended[5]
17	16	62+72	**16**	1.18	-113		Vegetative/mat/roll erosion control sufficient
18	17	68+08	**17**	2.21	6	X	Robust erosion control recommended
19	18	72+46	**18**	1.01	128		Vegetative/mat/roll erosion control sufficient
21	19	84+70	**19**	1.27	-118		Vegetative/mat/roll erosion control sufficient
23	20	91+36	**20**	1.65	-43	X[3]	Robust erosion control recommended
25	21	94+39	**21**	4.56	-113	X	Robust erosion control recommended
27	22	99+99	**22**	0.68	-144		Vegetative/mat/roll erosion control sufficient
29	23	106+50	**23**	1.14	-178		Vegetative/mat/roll erosion control sufficient
31	24	117+21	**24**	1.17	-99	X[4]	Robust erosion control for structural protection

psf = pounds per square feet

1 Equation 4 from the Integrated Streambank Protection Guidelines (WSAHGP 2002) as presented in Appendix B.
2 Appendix B provides additional detail on erosion control techniques.
3 Because the cross section is located in proximity to a bend (Figure B-1), robust erosion control is recommended.
4 Structural protection is highly recommended for cross sections 6 and 24 for ponds and road protection.
5 Visual inspection (Figure B-1) indicates a relatively straight section of the river. Vegetative, mat, or coir rolls should suffice.

Appendix A
Hydraulic Calculations

Attachment 1

Peak Riverflow Data

Water Resources

Data Category: Surface Water | Geographic Area: Montana | go

Peak Streamflow for Montana

USGS 12324200 Clark Fork at Deer Lodge MT

Available data for this site: Station home page | GO

Powell County, Montana
Hydrologic Unit Code 17010201
Latitude 46°23'52", Longitude 112°44'31" NAD27
Drainage area 995.00 square miles
Gage datum 4,502.2 feet above sea level NGVD29

Output formats

- Table
- Graph
- Tab-separated file
- WATSTORE formatted file
- Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1979	May 25, 1979	3.34	697
1980	May 26, 1980	4.58	1,710
1981	May 23, 1981	5.35	2,500
1982	Jun. 25, 1982	4.39	1,450
1983	Jul. 10, 1983	4.09	1,190
1984	Jun. 22, 1984	4.67	1,730
1985	May 04, 1985	3.16	492
1986	Feb. 25, 1986	5.20	2,090
1987	May 28, 1987	3.33	463
1988	Apr. 22, 1988	3.20	409
1989	Mar. 09, 1989	4.51	1,430
1990	May 31, 1990	3.34	507

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1991	Jun. 08, 1991	4.02	1,020
1992	Nov. 05, 1991	3.15	367
1993	Jun. 17, 1993	3.54	613
1994	May 13, 1994	3.27	462
1995	Jun. 07, 1995	4.17	1,240
1996	Feb. 08, 1996	4.46	1,400
1997	Jun. 14, 1997	5.07	2,020
1998	Jul. 04, 1998	4.23	1,200
1999	Jun. 04, 1999	3.83	819
2000	Nov. 26, 1999	2.95	263
2001	Jun. 04, 2001	3.04	310
2002	Jun. 10, 2002	3.34	461
2003	Jun. 01, 2003	4.11	1,060

Questions about data gs-w-mt_NWISWeb_Data_Inquiries@usgs.gov
Feedback on this websitegs-w-mt_NWISWeb_Maintainer@usgs.gov
Surface Water for Montana: Peak Streamflow
http://waterdata.usgs.gov/mt/nwis/peak?

Top
Explanation of terms

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Attachment 2

FlowMaster Output—Pre-Construction

Pre-Construction

Label	Worksheet Type	Mannings Coefficient	Depth (ft)	Slope (ft/ft)	Left Side Slope (H : V)	Right Side Slope (H : V)	Bottom Width (ft)	Discharge (cfs)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)	Critical Depth (ft)	Critical Slope (ft/ft)	Velocity (ft/s)	Velocity Head (ft)	Specific Energy (ft)	Froude Number	Flow Type
Cross Section 01 - Pre-Construction	Rectangular	0.033	5.31	0.002900			70.00	2,500.00	372.0	80.63	70.00	3.41	0.011934	6.72	0.70	6.02	0.51	Subcritical
Cross Section 02 - Pre-Construction	Rectangular	0.033	4.19	0.002900			100.00	2,500.00	418.7	108.37	100.00	2.69	0.012238	5.97	0.55	4.74	0.51	Subcritical
Cross Section 03 - Pre-Construction	Trapezoidal	0.033	7.84	0.001900	0.50	2.00	40.00	2,500.00	390.5	66.30	59.60	4.70	0.010892	6.40	0.64	8.48	0.44	Subcritical
Cross Section 04 - Pre-Construction	Trapezoidal	0.033	6.71	0.002200	2.00	0.25	50.00	2,500.00	386.1	71.92	65.10	4.13	0.011133	6.48	0.65	7.36	0.47	Subcritical
Cross Section 05 - Pre-Construction	Rectangular	0.033	6.10	0.001400			80.00	2,500.00	488.4	92.21	80.00	3.12	0.012004	5.12	0.41	6.51	0.37	Subcritical
Cross Section 06 - Pre-Construction	Trapezoidal	0.033	5.97	0.005300	1.50	0.25	40.00	2,500.00	270.1	56.92	50.45	4.78	0.011121	9.26	1.33	7.30	0.71	Subcritical
Cross Section 07 - Pre-Construction	Trapezoidal	0.033	6.11	0.005200	0.25	1.00	40.00	2,500.00	267.8	54.94	47.64	4.83	0.011242	9.33	1.35	7.47	0.69	Subcritical
Cross Section 08 - Pre-Construction	Rectangular	0.033	4.25	0.006900			65.00	2,500.00	276.4	73.50	65.00	3.58	0.011922	9.04	1.27	5.52	0.77	Subcritical
Cross Section 09 - Pre-Construction	Rectangular	0.033	3.79	0.003600			105.00	2,500.00	398.5	112.59	105.00	2.60	0.012306	6.27	0.61	4.41	0.57	Subcritical
Cross Section 11 - Pre-Construction	Trapezoidal	0.033	7.91	0.005200	0.25	1.50	25.00	2,500.00	252.5	47.41	38.84	6.27	0.011453	9.90	1.52	9.43	0.68	Subcritical
Cross Section 12 - Pre-Construction	Rectangular	0.033	5.25	0.001400			100.00	2,500.00	525.0	110.50	100.00	2.69	0.012238	4.76	0.35	5.60	0.37	Subcritical
Cross Section 13 - Pre-Construction	Trapezoidal	0.033	8.05	0.002200	0.50	0.50	40.00	2,500.00	354.2	57.99	48.05	4.85	0.011289	7.06	0.77	8.82	0.46	Subcritical
Cross Section 14 - Pre-Construction	Trapezoidal	0.033	5.88	0.006700	0.25	5.00	30.00	2,500.00	267.2	66.04	60.87	5.13	0.011147	9.36	1.36	7.24	0.79	Subcritical
Cross Section 15 - Pre-Construction	Trapezoidal	0.033	7.65	0.008900	0.25	1.50	20.00	2,500.00	204.1	41.66	33.38	7.05	0.011783	12.25	2.33	9.98	0.87	Subcritical
Cross Section 16 - Pre-Construction	Rectangular	0.033	5.32	0.001900			85.00	2,500.00	452.2	95.64	85.00	3.00	0.012054	5.53	0.48	5.79	0.42	Subcritical
Cross Section 17 - Pre-Construction	Trapezoidal	0.033	6.40	0.004000	0.25	2.00	40.00	2,500.00	301.9	60.90	54.39	4.73	0.011072	8.28	1.07	7.46	0.62	Subcritical
Cross Section 18 - Pre-Construction	Trapezoidal	0.033	6.38	0.002000	0.25	0.75	60.00	2,500.00	403.0	74.55	66.38	3.74	0.011373	6.20	0.60	6.98	0.44	Subcritical
Cross Section 18A - Pre-Construction	Trapezoidal	0.033	6.15	0.001800	0.25	0.50	67.50	2,500.00	429.4	80.72	72.11	3.47	0.011531	5.82	0.53	6.68	0.42	Subcritical
Cross Section 19 - Pre-Construction	Rectangular	0.033	6.12	0.001600			75.00	2,500.00	458.9	87.24	75.00	3.26	0.011963	5.45	0.46	6.58	0.39	Subcritical
Cross Section 19A - Pre-Construction	Trapezoidal	0.033	5.93	0.002600	0.25	1.50	57.50	2,500.00	372.1	74.32	67.89	3.81	0.011238	6.72	0.70	6.64	0.51	Subcritical
Cross Section 20 - Pre-Construction	Trapezoidal	0.033	6.45	0.003700	0.25	2.50	40.00	2,500.00	315.3	64.02	57.74	4.68	0.011060	7.93	0.98	7.43	0.60	Subcritical
Cross Section 21 - Pre-Construction	Rectangular	0.033	4.67	0.007400			55.00	2,500.00	256.6	64.33	55.00	4.00	0.011979	9.74	1.48	6.14	0.80	Subcritical
Cross Section 22 - Pre-Construction	Rectangular	0.033	6.79	0.001000			80.00	2,500.00	543.5	93.59	80.00	3.12	0.012004	4.60	0.33	7.12	0.31	Subcritical
Cross Section 22A - Pre-Construction	Rectangular	0.033	5.85	0.001600			80.00	2,500.00	468.2	91.70	80.00	3.12	0.012004	5.34	0.44	6.30	0.39	Subcritical
Cross Section 23 - Pre-Construction	Rectangular	0.033	5.37	0.002100			80.00	2,500.00	429.7	90.74	80.00	3.12	0.012004	5.82	0.53	5.90	0.44	Subcritical
Cross Section 23A - Pre-Construction	Rectangular	0.033	5.13	0.002000			87.50	2,500.00	449.2	97.77	87.50	2.94	0.012082	5.57	0.48	5.62	0.43	Subcritical
Cross Section 24 - Pre-Construction	Rectangular	0.033	4.94	0.001900			95.00	2,500.00	469.2	104.88	95.00	2.78	0.012173	5.33	0.44	5.38	0.42	Subcritical
Cross Section 25 - Pre-Construction	Trapezoidal	0.033	6.67	0.001800	2.00	0.50	55.00	2,500.00	422.2	77.36	71.67	3.88	0.011075	5.92	0.54	7.21	0.43	Subcritical

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Appendix A-3

Hydraulic Parameters

Hydraulic Parameters

The hydraulic parameters of the river were calculated using FlowMaster, which applies Manning's equation to determine velocity and capacity of the modeled channel section. A pre-construction scenario (river conditions prior to remediation or restoration activities) was modeled for the 25 cross sections surveyed along the Clark Fork River at GRKO (Brown and Associates 2002). For the pre-construction scenario, the U.S. Geological Survey (USGS) peak flow of 2,500 cfs (documented in 1981 at the Deer Lodge gauging station number USGS 12324200) (USGS 2002) and Manning's coefficient of 0.033 (Swanson 2002) were used as FlowMaster input parameters. The sideslopes of each cross section were calculated using AutoCAD and input to the model. Appendix A - Attachment 2 contains FlowMaster pre-construction output sheet.

Appendix B

Erosion Control

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TABLE OF CONTENTS

Engineering Parameters

The shear stresses (erosional forces along a bank or bed) were calculated for the 25 cross sections surveyed along the Clark Fork River (Brown and Associates 2002). Shear stress is an important parameter in riverbank stabilization design as all material used for erosion control must be able to withstand the expected shear stresses or the banks will continue to fail. In this case, shear stresses were calculated from equations in the *Integrated Streambank Protection Guidelines* (WSAHGP 2002). The FlowMaster output information for the cross sections was used to calculate bed and bank shear stresses for straight sections. The bed shear stresses ranged from 0.32 pounds per square foot (psf) to 2.43 psf. The bank shear stresses ranged from 0.25 psf to 1.68 psf. Vegetative erosion control methods will tolerate this range of bed and bank shear stresses in straight sections. Appendix B of this document contains the details of the shear stress calculations used for riverbank stabilization design and erosion control material tolerance for shear stress.

Shear stresses in bends were then calculated from bed shear stress in the straight sections and using FlowMaster output information. Equations in the *Integrated Streambank Protection Guidelines* (WSAHGP 2002) were used. The shear stress in the bends ranged from 0.68 psf to 4.56 psf, which is the primary indicator that vegetation may not provide sufficient erosion control to tolerate the range of shear stresses. Appendix B contains the details of the shear stress calculations used for riverbank stabilization design.

The radius of curvature (angle at the cross section meander calculated from AutoCAD) was also used to indicate sections of high erosion in bends. The general rule of thumb is that a bank will erode when the radius of curvature in a bend is greater than three times the channel bottom width. Though shear stress was the primary indicator for erosion control needs, the radius of curvature data provided a secondary element for evaluation. These data tables are presented as part of Appendix B.

The FlowMaster output information and the radius of curvature were used to calculate the scour depth (depth of potential erosion that requires reinforcing to prevent further sediment movement) at each bend cross section. Scour depths were calculated from equations in the *Integrated Streambank Protection Guidelines* (WSAHGP 2002). Pre-construction scour depths ranged from 1 to 16 ft, which indicates an engineered erosion control method should be applied to the bends. These data were used to cross check shear stress information and erosion control location determination techniques. Appendix B contains the details of the erosion control calculations used for riverbank stabilization design.

Table B-1: GRKO Erosion Control Design—Pre-Construction Shear Stress

Cross Section	Channel Slope (ft/ft) [1]	Flow Area (ft^2) [2]	Wetted Perimeter (ft) [2]	Hydraulic Radius (ft) [3]	Bed Shear Stress in Straight Sections (psf) [4]	Bank Shear Stress in Straight Sections (psf) [5]	Shear Stress in Bends (psf) [8]	K_b [7]	Radius of Curvature (ft) [6]	Bottom Width of Channel (W) (ft) [6]	3 times Bottom Width (3W)	Bend Radius less 3W [12] (+ = >3W)	Erosion Control Comments
1	0.0029	372.00	80.63	4.61	0.83	0.67	N/A	N/A	0	70	210	-210	STRAIGHT
1A	0.0029	395.35	94.50	4.18	0.76	0.61	N/A	N/A	0	85	255	-255	Extrapolated half-way between cross sections
2	0.0029	418.70	108.37	3.86	N/A	N/A	1.09	1.43	603.74	100	300	304	Vegetative/mat/roll erosion control sufficient
2A	0.0019	404.60	87.34	4.63	0.55	0.44	N/A	N/A	0	70	210	-210	Extrapolated half-way between cross sections
3	0.0019	390.50	66.30	5.89	N/A	N/A	0.99	1.79	136.56	40	120	17	Robust erosion control recommended [9]
3A	0.0022	388.30	69.11	5.62	0.77	0.62	N/A	N/A	0	45	135	-135	Extrapolated half-way between cross sections
4	0.0022	386.10	71.92	5.37	N/A	N/A	1.71	2.22	45.42	50	150	-105	Vegetative/mat/roll erosion control sufficient
4A	0.0014	437.25	82.07	5.33	0.47	0.37	N/A	N/A	0	65	195	-195	Extrapolated half-way between cross sections
5	0.0014	488.40	92.21	5.30	N/A	N/A	0.78	1.68	337.39	80	240	97	Vegetative/mat/roll erosion control sufficient
5A	0.0053	379.25	74.57	5.09	1.68	1.35	N/A	N/A	0	60	180	-180	Extrapolated half-way between cross sections
6	0.0053	270.10	56.92	4.75	N/A	N/A	3.45	2.05	73.96	40	120	-46	Robust erosion control required, structural protection [10]
6A	0.0052	268.95	55.93	4.81	1.56	1.25	N/A	N/A	0	40	120	-120	Extrapolated half-way between cross sections
7	0.0052	267.80	54.94	4.87	N/A	N/A	2.82	1.81	133.42	40	120	13	Robust erosion control recommended
7A	0.0069	272.10	64.22	4.24	1.82	1.46	N/A	N/A	0	52.5	157.5	-158	Extrapolated half-way between cross sections
8	0.0069	276.40	73.50	3.76	N/A	N/A	2.79	1.53	343.09	65	195	148	Robust erosion control NOT recommended [11]
8A	0.0036	337.45	93.05	3.63	0.81	0.65	N/A	N/A	0	85	255	-255	Extrapolated half-way between cross sections
9	0.0036	398.50	112.59	3.54	N/A	N/A	1.63	2.00	225.27	105	315	-90	Vegetative/mat/roll erosion control sufficient
9A	0.0043	355.54	91.34	3.89	1.04	0.84	N/A	N/A	0	82.5	247.5	-248	Extrapolated half-way between cross sections
10	0.0043	312.57	70.09	4.46	1.20	0.96	N/A	N/A	0	60	180	-180	STRAIGHT
10A	0.0052	282.54	58.75	4.81	1.56	1.25	N/A	N/A	0	42.5	127.5	-128	Extrapolated half-way between cross sections
11	0.0052	252.50	47.41	5.33	N/A	N/A	2.93	1.88	72	25	75	-3	Robust erosion control recommended
11A	0.0014	388.75	78.96	4.92	0.43	0.34	N/A	N/A	0	63	187.5	-188	Extrapolated half-way between cross sections
12	0.0014	525.00	110.50	4.75	N/A	N/A	0.96	2.24	82.12	100	300	-218	Vegetative/mat/roll erosion control sufficient
12A	0.0022	439.60	84.25	5.22	0.72	0.57	N/A	N/A	0	70	210	-210	Extrapolated half-way between cross sections
13	0.0022	354.20	57.99	6.11	N/A	N/A	1.49	2.08	67.05	40	120	-53	Vegetative/mat/roll erosion control sufficient
13A	0.0067	310.70	62.02	5.01	2.09	1.68	N/A	N/A	0	35	105	-105	Extrapolated half-way between cross sections
14	0.0067	267.20	66.04	4.05	N/A	N/A	3.52	1.68	125.37	30	90	35	Robust erosion control NOT recommended [11]
14A	0.0089	235.65	53.85	4.38	2.43	1.94	N/A	N/A	0	25	75	-75	Extrapolated half-way between cross sections
15	0.0089	204.10	41.66	4.90	N/A	N/A	3.70	1.52	106.54	20	60	47	Robust erosion control NOT recommended [11]
15A	0.0019	328.15	68.65	4.78	0.57	0.45	N/A	N/A	0	52.5	157.5	-158	Extrapolated half-way between cross sections
16	0.0019	452.20	95.64	4.73	N/A	N/A	1.18	2.08	142.2	85	255	-113	Vegetative/mat/roll erosion control sufficient
16A	0.0040	377.05	78.27	4.82	1.20	0.96	N/A	N/A	0	62.5	187.5	-188	Extrapolated half-way between cross sections
17	0.0040	301.90	60.90	4.96	N/A	N/A	2.21	1.84	125.95	40	120	6	Robust erosion control recommended
17A	0.0020	352.45	67.73	5.20	0.65	0.52	N/A	N/A	0	50	150	-150	Extrapolated half-way between cross sections
18	0.0020	403.00	74.55	5.41	N/A	N/A	1.01	1.55	308.16	60	180	128	Vegetative/mat/roll erosion control sufficient
18A	0.0018	429.40	80.72	5.32	0.60	0.48	N/A	N/A	0	67.5	202.5	-203	STRAIGHT
19	0.0016	458.90	87.24	5.26	N/A	N/A	1.27	2.13	106.93	75	225	-118	Vegetative/mat/roll erosion control sufficient
19A	0.0026	372.10	74.32	5.01	0.81	0.65	N/A	N/A	0	57.5	172.5	-173	STRAIGHT
20	0.0037	315.30	64.02	4.93	N/A	N/A	1.65	2.04	77.24	40	120	-43	Robust erosion control recommended [9]
20A	0.0074	285.95	64.18	4.46	2.06	1.65	N/A	N/A	0	48	142.5	-143	Extrapolated half-way between cross sections
21	0.0074	256.60	64.33	3.99	N/A	N/A	4.56	2.21	51.79	55	165	-113	Robust erosion control recommended
21A	0.0010	400.05	78.96	5.07	0.32	0.25	N/A	N/A	0	68	202.5	-203	Extrapolated half-way between cross sections
22	0.0010	543.50	93.59	5.81	N/A	N/A	0.68	2.17	96.28	80	240	-144	Vegetative/mat/roll erosion control sufficient
22A	0.0016	468.20	91.70	5.11	0.51	0.41	N/A	N/A	0	80	240	-240	STRAIGHT

Table B-1: GRKO Erosion Control Design—Pre-Construction Shear Stress

Cross Section	Channel Slope (ft/ft) [1]	Flow Area (ft^2) [2]	Wetted Perimeter (ft) [2]	Hydraulic Radius (ft) [3]	Bed Shear Stress in Straight Sections (psf) [4]	Bank Shear Stress in Straight Sections (psf) [5]	Shear Stress in Bends (psf) [8]	K_b [7]	Radius of Curvature (ft) [6]	Bottom Width of Channel (W) (ft) [6]	3 times Bottom Width (3W)	Bend Radius less 3W[12] (+ = >3W)	Erosion Control Comments
23	0.0021	429.70	90.74	4.74	N/A	N/A	1.14	2.25	62.38	80	240	-178	Vegetative/mat/roll erosion control sufficient
23A	0.0020	449.20	97.77	4.59	0.57	0.46	N/A	N/A	0	87.5	262.5	-263	STRAIGHT
24	0.0019	469.20	104.88	4.47	N/A	N/A	1.17	2.03	185.66	95	285	-99	Robust erosion control for structural protection [10]
24A	0.0018	445.70	91.12	4.89	0.55	0.44	N/A	N/A	0	75	225	-225	Extrapolated half-way between cross sections
25	0.0018	422.20	77.36	5.46	N/A	N/A	1.06	1.94	138.47	55	165	-27	Vegetative/mat/roll erosion control sufficient

Notes:

cfs	cubic feet per second
ft	feet
ft/ft	feet per feet
psf	pounds per square feet

1 Calculated based on the length between cross sections and the elevation change.
2 Determined from FlowMaster program, see Appendix A. Some are averages from surrounding sections.
3 Calculated from the flow area and wetted perimeter.
4 Equation 1 from the Integrated Streambank Protection Guidelines as presented within this appendix.
5 Equation 2 from the Integrated Streambank Protection Guidelines as presented within this appendix.
6 Determined from surveyed AutoCAD drawings.
7 Bend coefficient from Equation 4 from the Integrated Streambank Protection Guidelines as presented in this appendix.
8 Equation 4 from the Integrated Streambank Protection Guidelines as presented within this appendix.
9 Due to cross section location in the proximity of a bend (Figure B-1), robust erosion control is recommended.
10 Structural protection is highly recommended for cross sections 6 and 24 for ponds and road protection.
11 Visual inspection (Figure B-1) indicates a relatively straight section of the river. Vegetative, mat, or coir rolls should suffice.
12 The bank will erode if the bend radius is greater than 3 times the stream width (USACE Tech Guideline 10, Hydraulic Design of Flood Control Channels).

The shear stress data presented above is based on the FlowMaster model. Field data may differ.

Table B-2: GRKO Erosion Control Design—Pre-Construction Hydraulic Parameters and *Scour Depths*

Cross Section	Channel Top Width (ft) [1]	Channel Bottom Width (ft) [1]	Side Slope East (Right) [1]	Side Slope West (Left) [1]	Depth to Groundwater (ft) [2]	FlowMaster Channel Type [3]	Channel Distance East (ft) [1]	Channel Distance West (ft) [1]	Length Between Cross Sections (ft) [1]	Upstream Invert (ft) [1]	Cross Section Invert (ft) [1]	Slope (ft/ft) [4]	Storm Flow (cfs) [5]	Manning's n Value [6]	Flow Depth (ft) [7]	Width of Flow (ft) [7]	Actual Channel Depth (ft) [1]	Actual Channel Area (ft^2) [8]	Radius of Curvature (degrees) [1]	Calculated Maximum Depth (ft) [9]	Scour Depth (ft) [10]	Comments
2	100	100	N/A	N/A	6.47	Rectangular	851.85	888.69	870.27	4497.5	4495.0	0.0029	2,500	0.033	4.19	100.00	4	400	603.74	6.81	3	
3	90	40	2:1	0.5:1	6.19	Trapezoidal	540.94	487.13	514.04	4495.0	4494.0	0.0019	2,500	0.033	7.84	59.60	5	325	136.56	10.09	2	Channel bottom width estimates based on up- and downstream widths
4	110	50	0.25:1	2:1	4.49	Trapezoidal	725.68	615.15	670.42	4494.0	4492.5	0.0022	2,500	0.033	6.71	65.10	5.5	440	45.42	12.78	6	Channel bottom width estimates based on up- and downstream widths
5	80	80	N/A	N/A	4.45	Rectangular	349.00	389.36	369.18	4494.0	4493.5	0.0014	2,500	0.033	6.10	80.00	4	320	337.39	7.01	1	
6	140	40	0.25:1	1.5:1	5.16	Trapezoidal	430.26	519.35	474.81	4493.5	4491.0	0.0053	2,500	0.033	5.97	50.45	6.5	585	73.96	21.93	16	
7	70	40	1:1	0.25:1	6.77	Trapezoidal	388.92	385.65	387.29	4491.0	4489.0	0.0052	2,500	0.033	6.11	47.64	5	275	133.42	10.54	4	Channel bottom width estimates based on up- and downstream widths
8	65	65	N/A	N/A	7.30	Rectangular	305.38	271.91	288.65	4491.0	4489.0	0.0069	2,500	0.033	4.25	65.00	4	260	343.09	6.80	3	
9	105	105	N/A	N/A	7.94	Rectangular	280.46	269.09	274.78	4491.0	4490.0	0.0036	2,500	0.033	3.79	105.00	5	525	225.27	9.33	6	
11	55	25	1.5:1	0.25:1	7.93	Trapezoidal	315.91	262.83	289.37	4488.5	4487.0	0.0052	2,500	0.033	7.91	38.84	6	240	72	11.58	4	Channel bottom width estimates based on up- and downstream widths
12	100	100	N/A	N/A	6.66	Rectangular	383.80	321.03	352.42	4487.0	4486.5	0.0014	2,500	0.033	5.25	100.00	5	500	82.12	9.46	4	
13	65	40	0.5:1	0.5:1	5.85	Trapezoidal	158.02	294.16	226.09	4487.0	4486.5	0.0022	2,500	0.033	8.05	48.05	5.5	288.75	67.05	11.37	3	Channel bottom width estimates based on up- and downstream widths
14	110	30	5:1	0.25:1	6.16	Trapezoidal	233.11	216.70	224.91	4488.5	4487.0	0.0067	2,500	0.033	5.88	60.87	5.5	385	125.37	11.78	6	
15	65	20	1.5:1	0.25:1	6.09	Trapezoidal	232.28	216.70	224.49	4487.0	4485.0	0.0089	2,500	0.033	7.65	33.38	6.5	276.25	106.54	14.94	7	
16	85	85	N/A	N/A	6.32	Rectangular	443.48	616.76	530.12	4487.0	4486.0	0.0019	2,500	0.033	5.32	85.00	4.5	382.5	142.2	8.47	3	
17	100	40	2:1	0.25:1	5.04	Trapezoidal	503.71	502.90	503.31	4485.0	4483.0	0.0040	2,500	0.033	6.40	54.39	5.5	385	125.95	13.09	7	
18	80	60	0.75:1	0.25:1	4.5	Trapezoidal	518.31	489.32	503.82	4483.0	4482.0	0.0020	2,500	0.033	6.38	66.38	5.5	385	308.16	10.04	4	Channel bottom width estimates based on up- and downstream widths
19	75	75	N/A	N/A	4.41	Rectangular	1297.71	1252.19	1274.95	4482.0	4480.0	0.0016	2,500	0.033	6.12	75.00	4	300	106.93	7.57	1	
20	65	40	2.5:1	0.25:1	3.17	Trapezoidal	650.56	700.52	675.54	4480.0	4477.5	0.0037	2,500	0.033	6.45	57.74	6	315	77.24	10.32	4	
21	55	55	N/A	N/A	1.71	Rectangular	325.78	353.85	339.82	4477.5	4475.0	0.0074	2,500	0.033	4.67	55.00	6	330	51.79	11.35	7	
22	80	80	N/A	N/A	2.53	Rectangular	500.57	489.17	494.87	4477.5	4477.0	0.0010	2,500	0.033	6.79	80.00	5	400	96.28	9.46	3	
23	80	80	N/A	N/A	1.83	Rectangular	731.22	674.15	702.69	4477.0	4475.5	0.0021	2,500	0.033	5.37	80.00	4.5	360	62.38	8.51	3	
24	95	95	N/A	N/A	N/A	Rectangular	832.22	726.76	779.49	4475.5	4474.0	0.0019	2,500	0.033	4.94	95.00	5	475	185.66	9.34	4	
25	90	55	0.5:1	2:1	N/A	Trapezoidal	735.07	961.47	848.27	4474.0	4472.5	0.0018	2,500	0.033	6.67	71.67	5.5	398.75	138.47	10.40	4	Channel bottom width estimates based on up- and downstream widths

Notes:

cfs cubic feet per second
ft feet
ft/ft feet per feet

1 Determined from surveyed AutoCAD drawings since this data is closer to actual.
2 Determined from surveyed AutoCAD drawings and June 2000 groundwater data from the William W. Woessner and Molly M. Johnson, Water Resource Characterization Report, January 2001.
3 Channel model used in hydraulic calculation for FlowMaster program, see Appendix A.
4 Calculated based on the length between cross sections and the elevation change.
5 Peak flow from U. S. Geological Survey Station 12324200 Clark Fork at Deer Lodge, Montana.
6 Manning's n value from Swanson 2002.
7 Determined from FlowMaster program, see Appendix A
8 Calculated based on the channel geometry.
9 Equation 9 for bend scour from the Integrated Streambank Protection Guidelines as presented within this appendix.
10 Scour depth is the Calculated Maximum Depth less the Flow Depth. Data is used to help identify areas in need of erosion control.

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Table B-3: GRKO Erosion Control Design—Engineered Stabilization Analysis, Robust Erosion Control Summary

Cross Section	Shear Stress in Bends > 2 (psf) [1]	Bend Radius > 3W	Visual Inspection for Logjam Needs	Erosion Control Comments	Use of Engineered Stabilization Techniques in Treatment Type 4
2	1.09	304		Vegetative/mat/roll erosion control sufficient	
3	0.99	17	X [2]	Robust erosion control recommended	Yes
4	1.71	-105		Vegetative/mat/roll erosion control sufficient	
5	0.78	97		Vegetative/mat/roll erosion control sufficient	
6	3.45	-46	X [3]	Robust erosion control required, structural protection	Yes
7	2.82	13	X	Robust erosion control recommended	Yes
8	2.79	148		Robust erosion control NOT recommended [4]	
9	1.63	-90		Vegetative/mat/roll erosion control sufficient	
11	2.93	-3	X	Robust erosion control recommended	Yes
12	0.96	-218		Vegetative/mat/roll erosion control sufficient	
13	1.49	-53		Vegetative/mat/roll erosion control sufficient	
14	3.52	35		Robust erosion control NOT recommended [4]	
15	3.70	47		Robust erosion control NOT recommended [4]	
16	1.18	-113		Vegetative/mat/roll erosion control sufficient	
17	2.21	6	X	Robust erosion control recommended	Yes
18	1.01	128		Vegetative/mat/roll erosion control sufficient	
19	1.27	-118		Vegetative/mat/roll erosion control sufficient	
20	1.65	-43	X [2]	Robust erosion control recommended	Yes
21	4.56	-113	X	Robust erosion control recommended	Yes
22	0.68	-144		Vegetative/mat/roll erosion control sufficient	
23	1.14	-178		Vegetative/mat/roll erosion control sufficient	
24	1.17	-99	X [3]	Robust erosion control for structural protection	Yes

NOTES:

psf pounds per square feet

1 Equation 4 from the Integrated Streambank Protection Guidelines as presented within this appendix.
2 Due to cross section location in the proximity of a bend (Figure B-1), robust erosion control is recommended.
3 Structural protection is highly recommended for cross sections 6 and 24 for ponds and road protection.
4 Visual inspection (Figure B-1) indicates a relatively straight section of the river. Vegetative, mat, or coir rolls should suffice.

DETERMINATION PROCESS:

Step 1 – Determine shear stress and note those close to 2, as they may require robust erosion control.

Step 2 – Determine the radius of curvature analogy and note those with radii close to or greater than 3 times the bottom width of the channel. Compare these results to the shear stress results. Any overlap is considered a great candidate.

Step 3 – Locate the cross sections of concern on the Figures 6-1 through 6-3. Make sure that the areas of concern make practical sense. Disregard any downstream straight sections. Identify areas that contain structures such as roads or ponds and factor the near-by cross section into the logjams.

Step 4 – Apply this information to cost tables in Appendix D.

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Table B-4: GRKO Erosion Control Design—Material Tolerances

Cross Section	Shear Stress in Bends (psf)	Straw with Net (<1.4)	Coir Mats & Fabrics (1.0-3.0)	Synthetic Mats (2.0-8.0)	Class A Vegetation (<3.7)	Class B Vegetation (<2.1)	Class C Vegetation (<1.0)	Class D Vegetation (<0.60)	Class E Vegetation (<0.40)	1" Diameter Gravel (<0.30)	2" Diameter Gravel (<0.70)	6" Rock Riprap (<2.0)	12" Rock Riprap (<4.0)	Engineered Stabilization Other Than Rock Mattresses
2	1.09	X	X		X	X						X	X	
3	0.99	X	X		X	X	X					X	X	
4	1.71		X		X	X						X	X	
5	0.78	X			X	X	X					X	X	
6	3.45			X	X								X	
7	2.82		X	X	X								X	
8	2.79		X	X	X								X	
9	1.63		X		X	X						X	X	
11	2.93		X	X	X								X	
12	0.96	X			X	X	X					X	X	
13	1.49		X		X	X						X	X	
14	3.52			X	X								X	
15	3.70			X	X								X	
16	1.18	X	X		X	X						X	X	
17	2.21		X	X	X								X	
18	1.01	X	X		X	X						X	X	
19	1.27	X	X		X	X						X	X	
20	1.65		X		X	X						X	X	
21	4.56			X										X
22	0.68	X	X		X	X	X				X	X	X	
23	1.14	X	X		X	X						X	X	
24	1.17	X	X		X	X						X	X	
25	1.06	X	X		X	X						X	X	

Notes:

1) Synthetics, gravel, and riprap are not preferred materials for use by the NPS.
2) Coir mats & fabric shear stress tolerances vary by product.
3) Synthetic mat shear stress tolerances vary by product.
4) Cost of substitute techniques for rock material or synthetics contributes to costing in Appendix D.

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Appendix C
Revegetation

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

CT	community type
GRKO	Grant-Kohrs Ranch National Historic Site
HT	habitat type
ROD	Record of Decision

1. INTRODUCTION

This section presents the various aspects of revegetating the riparian corridor at Grant-Kohrs Ranch National Historic Site (GRKO). It presents the revegetation goals, implementation, best management practices, and long-term monitoring. It does not include the various aspects of site grading, soil treatment, excavation, and planting medium preparation. Such reclamation practices would include clearing and grubbing impacted woody vegetation, soil treatment (either removal or in situ treatment), cover soil application, and grading and contouring, all of which is presented in the ROD (p. 2-114 through 2-119) and would be incorporated into the overall site-grading plan.

2. GOALS

The primary goal of the revegetation plan is to re-establish the plant communities presented in Appendix E of the Record of Decision (ROD) for the Clark Fork Operable Unit (EPA 2004). These were developed by comparing existing communities on GRKO to similar vegetation types published in *Classification and Management of Montana's Riparian and Wetland Sites* (Hansen et al. 1995). This comparison identified 15 vegetation habitat types (HT) or community types (CT) that would reflect historical conditions. Eight of these HT/CTs currently exist on GRKO, encompassing 39.5 percent of the area.

The 15 baseline HT/CTs would provide a diverse structural riparian ecosystem that would include approximately 20.5 percent grass, sedge, and forb-dominated, 68.5 percent shrub- and shrub/herb-dominated, and 11 percent tree-dominated HT/CTs. Table 1 lists the proposed restoration goals for the 122-acres of injured soils within the riparian corridor. Geyer willow/bluejoint reedgrass water birch, geyer willow/beaked sedge, sandbar willow, and black cottonwood/red-osier dogwood would be the most extensive HT/CTs. Of these, only the geyer willow/bluejoint reedgrass, and black cottonwood/red-osier dogwood HT/CTs do not currently exist in the riparian corridor.

3. IMPLEMENTATION

3.1 Preservation of Existing Vegetation

In the riparian corridor of GRKO, approximately 53 acres of dense woody vegetation has been identified for potential preservation or interplanting. These areas generally met the baseline reference standards, or they were adapted to site conditions, as exemplified by high stem density or large mass, and a vegetative cover of woody species of more than 50 percent. Of this total, approximately 20 acres had

Table 1. Revegetation Goals

Plant Community Common Name	Vegetation Coverage 2000 (percent)	Vegetation Coverage 2000 (acres)	Vegetation Coverage Goal (%) [1] range (average)	Vegetation Coverage Goal [2] (acres-average)
Trees				
Black Cottonwood/Red-Osier Dogwood CT	0	0	8–12 (10)	12.2
Quaking Aspen/Bluejoint Reedgrass HT	0	0	<1 (1)	1.2
Trees subtotal	0	0	9–13 (11)	13.4
Shrubs				
Geyer Willow/Bluejont Reedgrass HT	0	0	18–23 (20.5)	25.0
Water Birch CT	14	17.6	12–18 (15)	18.3
Geyer Willow/Beaked Sedge HT	10.9	13.8	12–18 (15)	18.3
Sandbar Willow CT	7.7	9.7	8–12 (10)	12.2
Woods Rose CT	1.0	1.2	2–4 (3)	3.7
Mountain Alder CT	0	0	2–4 (3)	3.7
Western Snowberry CT	2.6	3.3	1–3 (2)	2.4
Shrubs subtotal	36.2	45.6	55–82 (68.5)	83.6
Graminoids				
Beaked Sedge HT	2.4	3.3	3–6 (4.5)	5.5
Bluejoint Reedgrass HT	0	0	3–6 (4.5)	5.5
Western Wheatgrass HT	0	0	3–6 (4.5)	5.5
Water Sedge HT	0.4	0.5	2–4 (3)	3.7
Common Spike Sedge HT	0.1	0.1	<1 (1)	1.2
Graminoids subtotal	2.9	3.9	12–23 (17.5)	21.4
Forbs				
Common Cattail HT	0.4	0.5	2–4 (3)	3.7
Forbs subtotal	0.4	0.5	2–4 (3)	3.7
Total	**39.5**	**50.0**	**78–122 (100)**	**122**

[1] Goals from Table E.2-1, Appendix E of the ROD. (EPA 2004)
[2] Percent x 122 acres = acres per type.

vegetation cover greater than 75 percent and would be preserved without treatment. The remainder would be interplanted (see below).

3.2 Species Selection

The relative species composition for the baseline communities was listed in Appendix E of the ROD (EPA 2004). When a detailed restoration plan is prepared, the composition of the species to be planted in each polygon would be determined.

3.3 Planting Techniques

Planting of the remediated and restored areas of GRKO would be phased over the 3 year restoration construction period. The planting phases would be designed to accomplish soil excavation and removal and seedbed/planting site preparation of a given area in a single construction season. Existing woody vegetation would be preserved and seeding and live plant materials would be used to revegetate restored areas.

3.3.1 Seeding

Seeding would occur in phases after soil disturbance to make the best use of seasonal moisture. Seedbed preparation would be accomplished by standard agricultural methods, including disking fertilizer into the soil and harrowing the seedbed. Broadcast and drill seeding would be used for seeding grasses, forbs, and some sedges and woody species, depending on species availability. Seeding in the fall would permit seed stratification and spring germination, as opposed to spring seeding and planting, which would be limited by wet soils. Temporary cover crops, such as wheat, would be used to stabilize soils until the planted herbaceous plants are established and to inhibit weed invasion.

3.3.2 Live Plant Materials

Live plant materials would be used in both the streambank stabilization and floodplain restoration areas. The planting techniques for the streambank stabilization zones were illustrated on pages B-10-B-12, Appendix B, ROD (EPA 2004). In general the streambank stabilization zone was divided into an inner 25-foot-wide zone and an outer 25-foot-wide zone.

The riverbank stabilization process will involve planting bags of willows and water birch. Sandbar willow will be the primary plant species used in the revegetation process along the inner 25-foot riverbank stabilization zone. Sandbar willow is a rhizomatous species that rapidly forms a deep, binding root mass that can stabilize riverbanks. It is a pioneer species and the dominant willow in the Clark Fork River system. It is not currently the dominant willow on GRKO. Along the rivers edge, or toe slopes, pre-vegetated coir or engineered bank stabilization would be implemented. In the outer 25-foot zone, containerized live shrubs, including serviceberry, chokecherry, snowberry, rose, and willows, among others, would be planted. A grass and forb herbaceous seed mix would be over seeded in the outer zone to achieve baseline communities.

Shrubs and trees would be live, bagged, containerized, bare-root, or stakes. Large shrubs will be used primarily to stabilize the top of slope of the riverbank areas. Mature willow transplants will be salvaged onsite, anchored, and tipped over the bank for stabilization. These materials would reduce water flow velocities immediately adjacent to the banks (Smith et al. 1998). Individual shrub masses must be evaluated and selected for vigor prior to salvage.

Willows would also be planted using live stakes or slips or prevegetated coir fiber rolls. Willows also can be obtained onsite in great numbers, thereby maintaining the genetic pool adapted to the site. Red-osier dogwood and selected other shrubs may also be established from cuttings. Live stakes are usually appropriate for those areas in contact to the capillary fringe. Prevegetated coir fiber rolls would be anchored at the toe of slope in all stream treatments.

Containerized shrubs would be used in the outer zone of the riparian buffer zone. The remainder of the floodplain would be planted primarily using containerized seedlings. The species and numbers needed to achieve baseline conditions would be assessed at the restoration design stage. Large numbers of many species would be required to revegetate the riparian corridor, so these shrubs would need to be contract grown to ensure that adequate stock is available when the planting season is optimal. An herbaceous seed mix prescription would be developed for each baseline community following Appendix E of the ROD (EPA 2004).

Emergent wetland communities would be established in low-lying areas where groundwater is at or near the surface during the growing season. Live emergent sprigs or shoots would be planted in suitable areas. Seeds for some emergent species may be collected, but finding enough seed crop may be difficult.

3.3.3 Interplanting (Vegetation Augmentation)

In areas with slightly impacted soils where woody shrub cover is between 50 and 75 percent, additional shrubs would be planted among and between the existing vegetation. Containerized shrubs would be used to fill in these relatively sparse areas and to add species diversity to the existing vegetation. Native baseline species also would be seeded by hand or by machine if stem density were sparse. The number of plants and the species to be planted to achieve the baseline communities would be identified in the field.

3.4 Irrigation

Irrigation during summer and fall would be required to ensure adequate moisture for seeding and transplanting success. An irrigation system would be designed and installed to provide a minimum of 1 inch of water per week from mid-June to mid-September for a period of 3 to 5 years. An uncontaminated water source would be used for irrigation. Herbaceous wetland species may need additional water to become established. Once they are established, high groundwater or drainage from irrigation ditches should sustain the emergent areas.

4. BEST MANAGEMENT PRACTICES

4.1 Grazing Management

A pasture management plan would be developed that fosters the overall objective of sustaining healthy riparian vegetation, while achieving the ranch experience for visitors to GRKO. Following the historical use of the ranch, the riparian corridor would be actively managed to achieve the plan objectives. Additional considerations for the riparian management plan are presented in Appendix C of the ROD (EPA 2004).

Several pastures would be identified and fenced. Cattle would be reintroduced to the riparian pastures on a deferred or rest-rotation grazing system once vegetation has been established. Stocking rates and season and duration of use would be established in the plan. Wildlife forage utilization would be considered in the plan. Pastures would be monitored for utilization, stocking rates, health of the native vegetation, streambank stability, and noxious weeds, among other features. Grazing periods and stocking rates would be adjusted to maintain proper utilization. If necessary, additional water sources would be developed away from the river to prevent bank destabilization by livestock.

4.2 Noxious Weed Control

GRKO currently has an abundance of noxious weeds. Ground disturbance associated with implementing remedy and restoration would provide good seedbeds for onsite and offsite sources of weed seed. Therefore, an integrated weed management plan would be developed and implemented as part of the overall operations at GRKO. Cooperation with university and county extension agents would be established during the design phase. In addition to the best management practices described below, weed prevention and management planning information for the Clark Fork River Operable Unit was presented in Appendix D of the ROD (EPA 2004).

Ground disturbance would be avoided in areas meeting the restoration objectives, such as areas of dense woody vegetation. To prevent additional weed colonization, disturbed areas would be quickly revegetated. Even with the establishment of a dense ground cover, weeds can be expected to invade the site. Weed populations would be eradicated after identification. Weed control would be accomplished by implementing cultural, biological, grazing, herbicide, hand-pulling, and cutting and mowing options (Appendix D; EPA 2004). The weed management program would be maintained and monitored for effectiveness in conjunction with the ongoing grazing management plan.

5. LONG-TERM MONITORING

Long-term monitoring of the revegetation areas on GRKO would be necessary to ensure the successful reestablishment of native plant communities in the riparian corridor. Performance standards for individual HT/CT were developed for species presence and abundance (Appendix E; EPA 2004). A quantitative vegetation-monitoring program would be designed and implemented in the first year after planting. The plan would monitor vegetation cover, frequency, richness, and diversity. The monitoring plan would be implemented for 15 years. The monitoring results would be compared to the restoration objectives to determine whether the desired mosaic of native plant communities are becoming established at an optimal rate of recovery.

6. REFERENCES

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Appendix D

Compliance with Federal, State, and Tribal Law

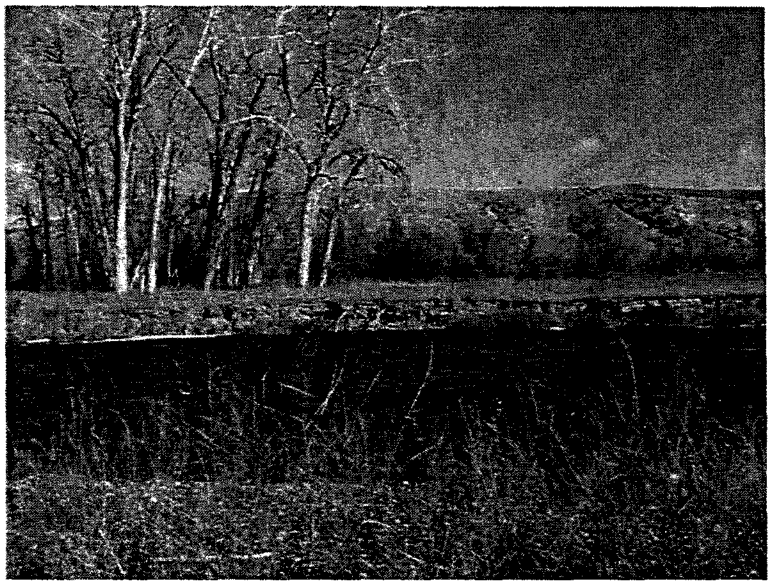
Compliance with Applicable Federal, State, and Tribal Laws

Federal		
Type	**Description**	**Citation**
Chemical	Groundwater Standards—Safe Drinking Water Act	40 CFR 141
Location	Fish and Wildlife Coordination Act	16 USC 661 and 40 CRF 6.302(g)
	Floodplain Management Order	40 CFR 6, Appendix A, Executive Order No. 11,988
	Protection of Wetlands	40 CFR 6, Appendix A, Executive Order No. 11,990
	Endangered Species Act	16 USC 1531-1544, 50 CFR 402, and 40 CFR 6.302(h)
	National Historic Preservation Act	16 USC 470 and 36 CFR 800
	Archaeological and Historic Preservation Act	16 USC 469 and 40 CFR 6.301(c)
	Historic Sites, Buildings, and Antiquities Act	16 USC 461, 16 USC 703, and 40 CFR 6.310(a)
	The Migratory Bird Treaty Act of 1918	16 USC 703-712
	Bald Eagle Protection Act	16 USC 668
	Resource Conservation and Recovery Act (RCRA)	40 CFR 264.18(a) and (b)
	Solid Waste Disposal in National Parks	16 USC 460l-22(c) and 36 CFR 6
	The National Park Service Organic Act	16 USC 1-3 and 36 CFR 1-0
	Grant-Kohrs Ranch Enabling Legislation	Pub. L. 92-406, 86 Stat 7632 [1972]
	Native American Grave Protection and Repatriation Act	25 USC 3001 and 43 CFR 10.1-10.17
Action	Solid Waste Generation	40 CFR 257.3-1(a), 257.3-3, and 257.3-4
	Surface Mining Control and Reclamation	30 CFR 816 and 784
	RCRA Requirements	40 CFR 264.116-119, 264.228(a)(2)(ii), and 264.228(a)(2)(iii)(B), (C), and (D)
	Clean Air Act—Air Standards	40 CFR 50
	Clean Water Act—Point Source Controls	40 CFR 121, 122, 125, 440.148
	Dredge and Fill Requirements	40 CFR 230
	Underground Injection Control	40 CFR 144
	Transportation of Hazardous Waste	40 CFR 263
State		
Type	**Description**	**Citation**
Chemical	Surface Water Quality Standards	75-5-101, MCA
	Groundwater Standards	75-5-101, MCA
Location	Floodplain and Floodway Management Act and Regulations	75-5-401 and -402, MCA, ARM 36-15-601, -602, and –701
	Solid Waste Management Regulations	75-10-201and -212 MCA and ARM 17-50-505
	Natural Streambed and Land Preservation Standards	87-5-502 and -504 and 75-7-101 and -102, MCA and ARM 36-2-410
Action	Water Quality Statute and Regulations	75-5-303 and -605 MCA and ARM 17-30-601, -705, -708, -1011, -1332, and -1342–1344
	Air Quality	75-2-101 MCA, ARM 17-8-220, -304, and -308, and ARM 17-24-761
	Solid Waste Management Regulations	75-10-206 MCA and ARM 17-50-505, -506, -511, -530, -531, -523, and –701
	Reclamation Requirements	82-4-201 - 254 MCA, ARM 26-4-505 and -641, 82-4-201, 17-24-501, -514, -519, -631, -635 - 637, -639, -640, -643, -645, -646, -703 -702, -703, -711, -713, -714, -716, -718, -719, -723, -726, -728, -733 and -750.

Notes:
ARM Administrative Rules of Montana
CFR Code of Federal Regulation
MCA Montana Code Annotated
USC United States Code

Part II: Bureau of Land Management

Federal Restoration Plan for BLM Parcels



Bureau of Land Management
Montana State Office
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Clark Fork River Operable Unit,
Milltown Reservoir/Clark Fork River
National Priorities List Site

September 2007

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1.0 DESCRIPTION OF THE RESOURCE

The Bureau of Land Management (BLM) manages 15 parcels within the Clark Fork River Operable Unit (CFROU) of the Milltown Reservoir/Clark Fork River NPL Site. These parcels contain a total area of approximately 2,409 acres, of which 475 acres are riparian lands (Figure A). These land parcels lie along approximately 43 miles of the Clark Fork River within Reaches B and C of the CFROU. Site data were obtained from ten of the 15 parcels for the purpose of site characterization and natural resource damage assessment (NRDA). These ten parcels were selected for sampling because of the prominence of the floodplain related to these particular tracts.

BLM land management is guided by the Federal Land Policy and Management Act (FLPMA) of 1976. This Act directs BLM to use "multiple use management," defined as

> ...management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people. FLPMA [43 U.S.C. 1702] Sec 103(c)

Specifically, FLPMA dictates, in part, that:

> ...the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resources, and archeological values...will preserve and protect certain public lands in their natural condition...will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation... [FLPMA, [43 U.S.C. 1702] Sec. 102(a)(8)]

The BLM tracts in this study are managed for the multiple purposes of wildlife habitat, livestock grazing, and recreation. The degree to which one purpose is emphasized over another varies from parcel to parcel.

2.0 INJURY DEFINITIONS

Soil injury is defined in 43 C.F.R. § 11.62 (e). According to this regulation, injury to geological resources has occurred if a release or threatened release of hazardous substances causes, or has the potential to cause, any of the following:

- pH<4.0 or >8.5;
- salt saturation yielding a salt saturation value >2 millimhos per centimeter in soil;
- decreased water holding capacity such that plant, microbial, or invertebrate populations are affected;
- impedance of soil microbial respiration to an extent that plant and microbial growth have been inhibited;
- inhibition of carbon mineralization resulting from a reduction in soil microbial populations;
- toxic response to soil invertebrates; or
- phytotoxic response, such as retardation of plant growth.

A condition satisfying any one of these definitions is sufficient to establish injury to the resource.

2.1 INJURY DETERMINATION AND QUANTIFICATION

Injury was based on historical information and more recent data gathered specifically to quantify injury to soils on the DOI lands. Recent data on riparian and upland soils are presented in six data reports (Gannon, 2002; Kapustka, 2002; Moore, 2000; Moore and Woessner, 2001; Moore *et al.*, 2001; and Woessner and Johnson, 2002). The quality of data was evaluated and found to be of sufficient quality for their intended uses (Neuman, 2001, 2002). Nearly all of the soil, sediment, and water data were found to meet the highest standards (i.e., enforcement quality as defined in the checklist procedures agreed to by ARCO and USEPA in 2000 for data generated at the Clark Fork River Superfund Sites).

2.2 BASELINE METALS CONDITIONS

Baseline concentrations of contaminants of concern (COC) represent the natural levels of these substances prior to mining activities. Previous reports as well as analyses of new data were considered in establishing baseline concentrations for each COC. In 2000, baseline concentrations were identified for As, Cd, Cu, Pb, and Zn from analyses of deep soil cores on the Grant-Kohrs Ranch National Historic Site (GRKO), a unit of the National Park Service that lies in Reach A of the CFROU. This information was reported by Moore and Woessner (2001; Table I). These data were compared to values reported from previous efforts to determine COC baseline concentrations.

Table I. Baseline CoC concentrations (ppm) at GRKO Compared to other studies in Montana.

CoC	GRKO Ranch [a]	Silver Bow Creek [b]	Clark Fork Tributaries [c]	Divide Creek and Little Blackfoot River [d]
As	10	11.1	26.5	27.8
Cd	1	n.d.	<2.5	1.2
Cu	16	26.6	27.0	34.2
Pb	17	19.5	24.0	35.9
Zn	49	98.5	94.0	102.2

[a] Moore and Woessner (2001); [b] Canonie (1992); [c] Moore *et al.* (1989); [d] Lipton *et al.* (1993)
n.d. = no data

2.3 BLM Geochemical Sampling Design and Locations

The sampling of BLM lands was designed to characterize the extent of contamination of soils near the current or previous channels of the Clark Fork River and therefore likely to have received deposits of mining/milling wastes from the Butte/Anaconda area (see Moore 2000; Figure A, Figure B, and Figure C). The number of sampling locations per site varied from 2 to 21. Due to these differences in sampling intensity and the expected differences in levels of COC among the Tracts, it may be best to consider each tract as a separate entity rather than group all into a single analysis. Here we present summaries of all tracts as well as for individual tracts.

Baseline concentrations of the COC established for the GRKO were applied to the BLM parcels for comparisons of the magnitude of contamination. These values are the most comprehensive data for the pre-mining period for the Clark Fork River.

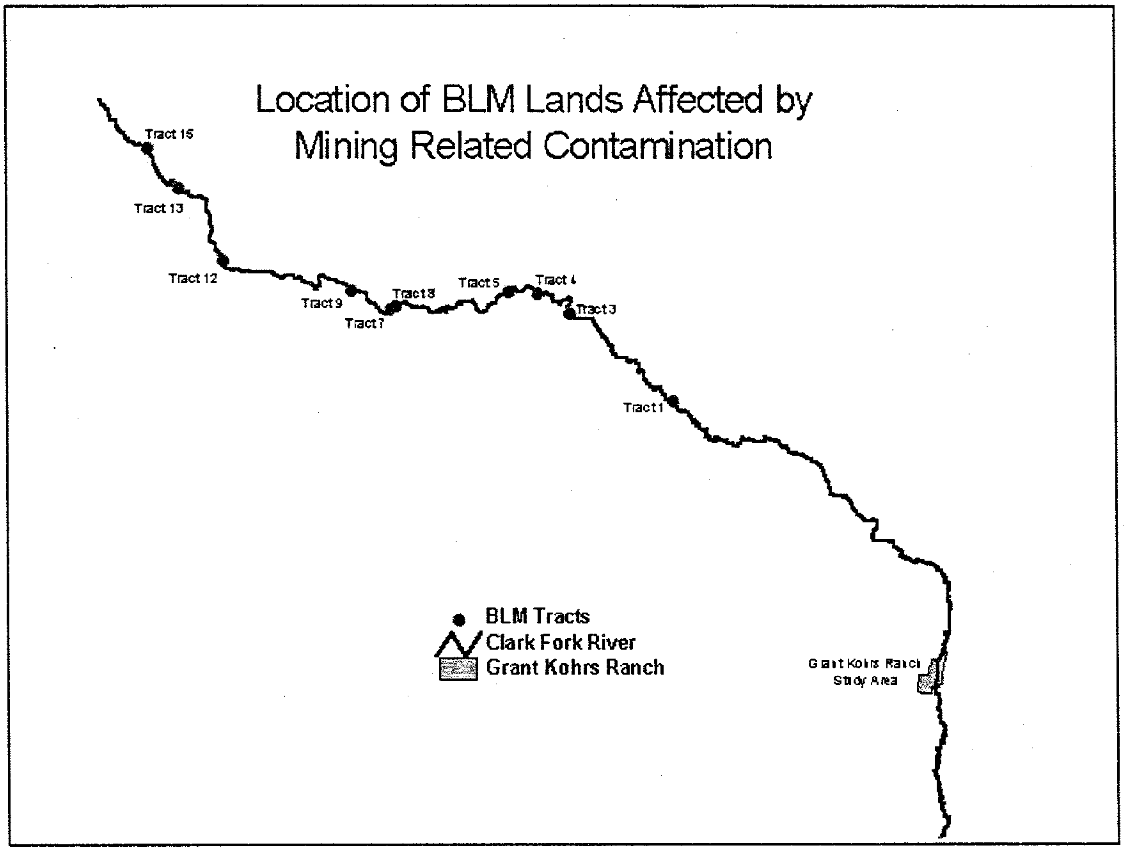

Figure A. BLM tracts in CFROU Reach B and C.

2.4 HISTORIC PHYTOTOXICITY TESTS

Several prior phytotoxicity studies have been performed on slickens in the CFROU. These include studies conducted for the RI/FS (Montana State University *et al.*, 1989a), the State of Montana Injury Assessment (Lipton, *et al.*, 1993), and an academic study (Rader *et al.*, 1997).

The Streambank Tailings and Revegetation Study (STARS), a component of the Silver Bow Creek RI/FS, was initiated to develop remedies for *in situ* treatment of tailings deposited along Silver Bow Creek (Montana State University *et al.*, 1989a). Greenhouse phytotoxicity tests were performed on six slickens soil samples. The test species were selected for their tolerance to acidic soils with high metal concentrations. The authors noted that no native plants had evolved tolerance mechanisms to cope with the conditions found on slickens, thus no native species were included in the tests. Nevertheless, even the tolerant species used in their tests had 100% failure (i.e., all plants in all trials either failed to germinate or died shortly after emergence).

Four slickens samples were evaluated for phytotoxic responses for the State of Montana Injury Assessment (LeJeune, *et al.*, 1996; Lipton, *et al.*, 1993). Alfalfa, lettuce, wheat, and hybrid poplar were used as test species. In two of the samples, germination and emergence of the herbaceous species was completely inhibited; in one sample emergence ranged from 0- to 25% for the three species; and in the fourth sample emergence ranged from 5- to 75%. Of those seedlings that survived, growth was significantly less than controls for alfalfa and lettuce in all samples, and was significantly less than controls in three of the four samples for wheat. Mortality of hybrid poplar was 100% in three of the four samples and was 40% in the fourth sample. Growth of shoots and roots in the fourth sample was inhibited by approximately 75% compared to controls. All four samples were classified as severely phytotoxic.

Rader *et al.* (1997) tested slickens soils from the GRKO at various dilutions (made with uncontaminated soil) using barnyard grass (*Echinochloa crusgalli*), lettuce (*Lactuca sativa*), radish (*Raphanus sativus*), and redtop bentgrass (*Agrostis gigantea*). They found that root growth was the most sensitive endpoint. In 100% slickens material, all four species, even the generally metals tolerant redtop bentgrass, were inhibited. Barnyard grass had limited emergence in treatments having 75% and 50% slickens with the remaining portion of the test soil made up with uncontaminated soil. Lettuce has a very low level of emergence at the 25% slickens level. Radish and redtop bentgrass emergence occurred only at slickens concentrations of 12.5% and less. Comparing root growth of emerging plants, barnyard grass was the most sensitive species.

3.0 FINDINGS

Seventy surface soil samples (upper 30 cm in 2000 upper 15 cm in 2001) were analyzed for COC. Comparison of the 30 cm and 15 cm soils samples showed no statistical difference in COC concentrations, permitting the 2000 and 2001 data to be pooled. Concentrations were generally lower from BLM parcels than upstream on the GRKO (Table II and Table III). Tracts 1, 5, and 9 had the highest concentrations of Cu and Zn. BLM levels were consistently above baseline including a maximum Cu concentration of 102.4 times the baseline. Zinc reached a maximum of 83.9 times the baseline. Mean values ranged from 3.2 times the baseline for Cd to 35.0 times the baseline for Cu.

Table II. Multiples of COC concentrations above baseline for ten BLM parcels.

Summary Statistic	As	Cd	Cu	Pb	Zn
Minimum	1.4	0.5	6.7	2.0	3.5
Maximum	17.1	11.4	102.4	17.5	83.9
Mean	6.2	3.2	35.0	5.8	17.9

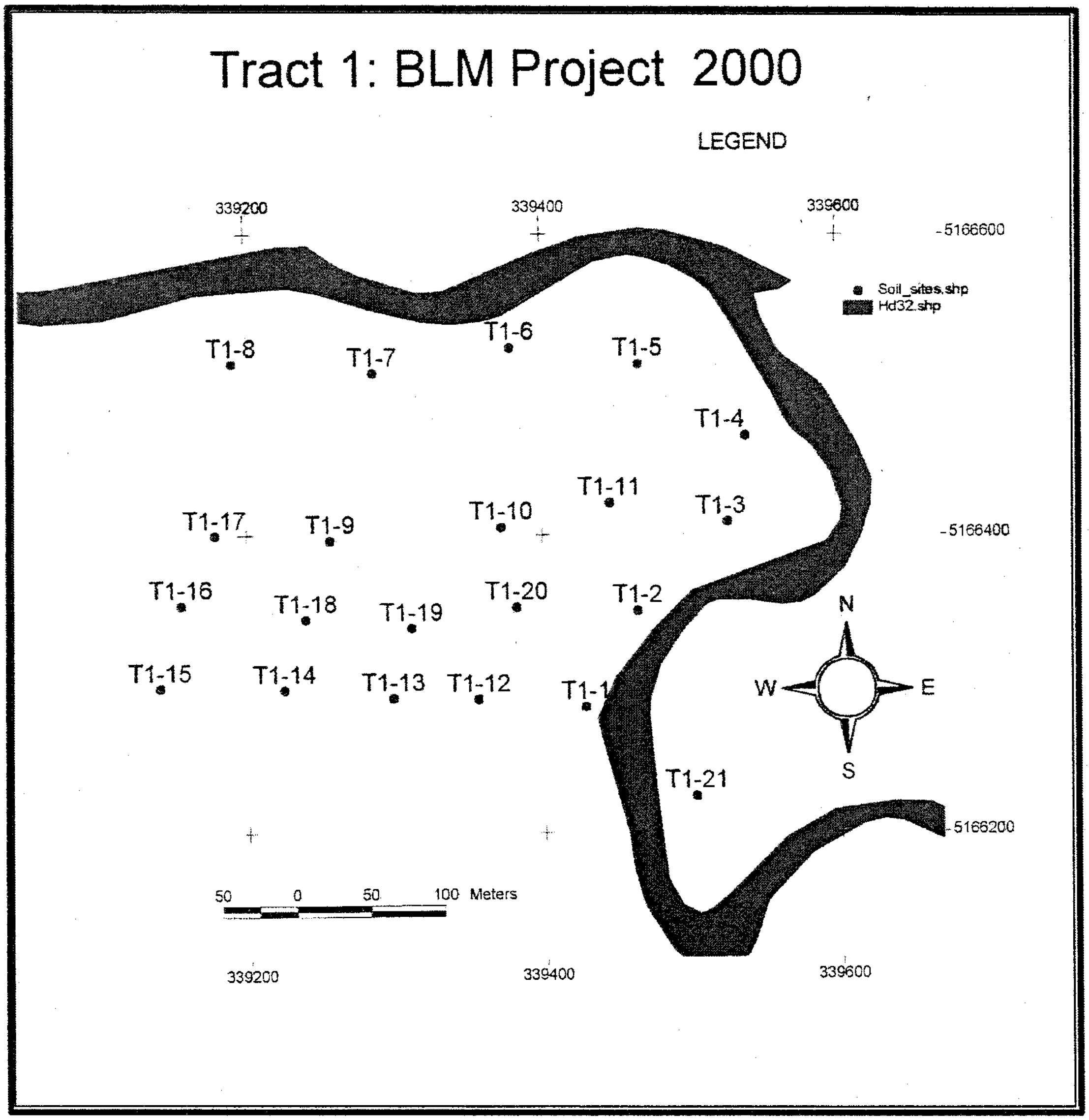

Figure B. Layout of sampling locations for BLM Tract 01.

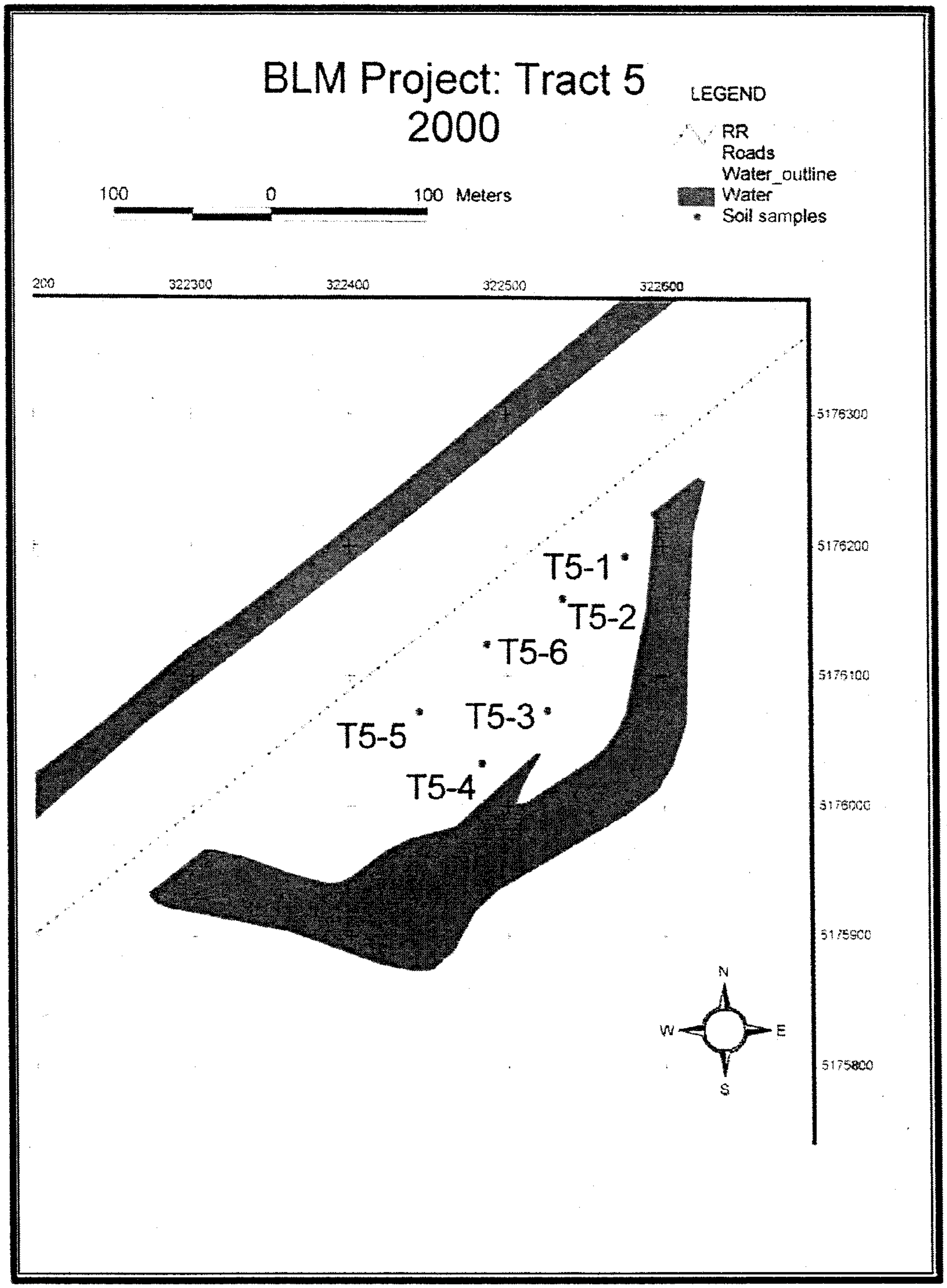

Figure C. Layout of sampling locations for BLM Tract 05.

Table III. COC values for the ten BLM tracts sampled in 2000 and 2001							
Tract	Summary Statistic	pH	As	Cd	Cu	Pb	Zn
T01	Minimum	7.00	14	1.0	107	34	187
	Maximum	7.92	171	11.4	1,299	173	4,113
	Median	7.46	60	3.8	532	74	757
	Mean	7.47	74	4.5	609	89	1,256
	Standard Deviation	0.24	43	3.2	384	43	1,096
T03	Minimum	7.11	29	1.6	210	50	450
	Maximum	8.19	84	4.2	1,100	230	1,100
	Median	7.93	49	2.4	395	76	695
	Mean	7.85	52	2.7	439	89	738
	Standard Deviation	0.27	16	0.9	237	47	202
T04	Minimum	7.31	19	1.4	359	107	215
	Maximum	8.14	115	2.6	1,054	218	460
	Median	7.77	39	1.7	447	139	237
	Mean	7.73	49	1.8	529	147	275
	Standard Deviation	0.29	34	0.4	264	38	93
T05	Minimum	7.08	50	1.8	448	95	241
	Maximum	8.06	158	3.9	1,638	298	652
	Median	7.53	128	3.0	1,367	204	579
	Mean	7.56	115	3.0	1,256	206	521
	Standard Deviation	0.36	40	0.8	433	77	149
T07	Minimum	7.90	42	2.7	400	73	770
	Maximum	8.19	67	4.0	550	92	1,100
	Median	8.05	55	3.4	475	83	935
	Mean	8.05	55	3.4	475	83	935
	Standard Deviation	0.21	18	0.9	106	13	233
T08	Minimum	7.11	22	1.9	170	42	640
	Maximum	7.74	37	2.8	310	87	950
	Median	7.66	33	2.3	240	54	830
	Mean	7.50	31	2.3	240	61	807
	Standard Deviation	0.34	8	0.5	70	23	156
T09	Minimum	7.58	68	3.4	550	96	810
	Maximum	8.30	95	4.9	960	120	1,500
	Median	7.95	81	4.3	780	120	1,300
	Mean	7.93	79	4.3	782	111	1,192
	Standard Deviation	0.26	11	0.6	156	12	298
T12	Minimum	7.59	22	0.5	190	45	170
	Maximum	8.05	68	4.8	580	110	1,900
	Median	7.87	44	2.3	370	65	770
	Mean	7.85	42	2.4	340	65	824
	Standard Deviation	0.13	16	1.3	125	20	530
T13	Minimum	7.39	24	1.5	200	43	480
	Maximum	7.89	50	2.9	380	80	770
	Median	7.76	32	2.2	280	58	645
	Mean	7.70	35	2.2	285	60	635
	Standard Deviation	0.22	12	0.6	78	16	124
T15	Minimum	6.86	25	1.3	200	42	430
	Maximum	7.73	50	3.0	480	81	770
	Median	7.74	38	2.2	340	62	600
	Mean	7.30	38	2.2	340	62	600
	Standard Deviation	0.62	18	1.2	198	28	240

3.1 Extrapolation of Phytotoxicity

The equations developed from laboratory phytotoxicity test results from GRKO were used to project phytotoxicity response based on pH-adjusted COC levels (As, Cu, and Zn). According to this method, some level of phytotoxicity is expected at each of the BLM parcels, with maximum phytotoxic effects (i.e., minimum plant growth) ranging from 3% to 28% phytotoxic impact to plant growth.

Table IV. Projected phytotoxicity of BLM tracts based on COC concentrations and equations derived from GRKO phytotoxicity test results.

Tract	alder			alfalfa			Phytotoxicity Rank			
	mean	minimum	maximum	Mean	minimum	maximum	N	P0	P1	P2
T01	90%	79%	100%	86%	72%	100%	21	7	13	1
T03	95%	84%	100%	94%	79%	100%	12	11	1	0
T04	96%	93%	100%	94%	90%	100%	6	6	0	0
T05	90%	81%	95%	86%	75%	93%	6	3	2	1
T07	94%	91%	96%	91%	88%	95%	2	1	1	0
T08	99%	97%	100%	98%	96%	100%	3	3	0	0
T09	93%	91%	93%	90%	87%	91%	5	4	1	0
T12	94%	87%	100%	92%	83%	99%	9	7	2	0
T13	93%	91%	95%	90%	87%	93%	4	3	1	0
T15	94%	90%	98%	92%	86%	98%	2	1	1	0
						Totals	70	46	22	2

N = number of samples; P0 = non-phytotoxic; P1 = mildly phytotoxic; P2 = moderately phytotoxic

4.0 CONCLUSIONS

Hazardous substances from large-scale mining operations upstream of the BLM parcels have contaminated the soils of these parcels. Contamination, like that upstream, is patchy and generally confined to the floodplain. The geochemical processes described for the upstream areas on the GRKO operate on the BLM soils, though the magnitude of contamination is less severe. Nevertheless, continuing releases of hazardous substances are occurring as COCs are mobilized by groundwater percolating and wicking through the soils. Erosion of stream banks also provides a continual source of newly exposed tailings.

The levels of contamination are significantly above background concentrations. At the higher concentrations, the levels are sufficiently high to cause phytotoxic responses in the species tested. These effects diminish the capacity of the lands to supply the expected services of the localized areas of contamination in the floodplain. Natural resource injuries include:

1. Alteration in the vegetative composition of the affected areas of the riparian corridor;
2. Loss of land due to tailings-related stream bank instability;
3. Reduced productivity in the affected areas;
4. Potential for increased ecological vulnerability to drought, fire, disease, and infestation in the affected areas;
5. Reduction in grazing area available for livestock;
6. Degradation of terrestrial wildlife habitat; and
7. Increased operational costs for management.

5.0 RESTORATION MEASURES

Injury to natural resources has occurred on 13 of the 15 BLM-managed tracts, negatively impacting 488 acres of low-lying areas within the river's floodplain. As demonstrated consistently in studies conducted in 1994, 1997, 2000, and 2001, these parcels have been impacted by the same river-transported metals and metalloids that have contaminated the GRKO. All of these hazardous substances have been found at the BLM parcels in concentrations substantially above background concentrations.

As demonstrated through site-specific studies by BLM and NPS, metals concentrations encountered within the BLM parcels are sufficient to cause toxicity to the plant growth that would have existed if not for the release of hazardous substances. Evidence of soil metals toxicity to plants suggests that the vegetation present is less diverse and has less overall structural diversity and vigor than uncontaminated soils would support (Lejeune et al, 1996; Rice, 2001). Metals concentrations are well in excess of phytotoxicity thresholds and exceed the concentration thresholds at abandoned mines on public lands that would require removal actions. While metals uptake by vegetation has not been analyzed on the BLM tracts, studies elsewhere in the Clark Fork River basin, where soils have similar metals contents, show moderate to high uptake levels (CH2M Hill, 1986). Such studies undertaken using soils collected at NPS lands showed marked metals uptake levels (Kapustka 2002). This toxicity produces a deleterious effect on plant shoot and root growth, resulting in diminished growth rates and seed and fruit production, leading to decreasing vegetation health and productivity and altered plant community composition.

The ecological services on these public lands include primarily wildlife habitat, with wildlife-based recreation and limited livestock grazing. Injuries to vegetation have adversely impacted plant community composition and vigor, both essential to these ecological services. Metals degradation of soils has historically reduced their capacity to support desirable wildlife forage or cover compared with baseline conditions in unaffected areas. Similar metals concentrations measured at comparable sites have been shown to be toxic to lower food chain components, affecting wildlife habitat health (CH2M Hill, 1986). In summary, the ecological services have been, and continue to be, injured to a measurable extent. This natural resource injury is documented in the "Natural Resource Injury Report on Riparian and Upland Areas of the Bureau of Land Management within the Clark Fork River Basin, Montana," (EP and T, 2002b).[1]

[1] The BLM Injury Report is available at the following web site: nps.gov/GRKO/naturalresourcemanagement/Superfund/BLM Injury Report

A primary concern arising from soil contamination is the alteration of native plant communities resulting in a degraded ecological system. This problem has been exacerbated by weed infestations that further weaken the native plant communities and increase the loss of ecological services these tracts would otherwise provide. For instance, in some locations changes in native plant communities have resulted in the absence of deep-penetrating roots, thereby subjecting stream banks to increased rates of erosion. Because large scale contaminant removal is not considered a viable restoration option in this part of the river due to cost, technical limitations, and other factors, weed control has been identified as a practical means of achieving restoration by promoting native plant community health.

BLM proposes to restore injured natural resources by implementing an aggressive weed control program consisting of treatment and re-vegetation within the 13 injured BLM tracts. The weed treatment strategy consists of an integrated weed management approach using proven mechanical, chemical, and bio-control methods. Each of the 13 tracts will have a specific weed treatment/control regimen, using some or all of these tools depending on the types of weeds present and levels of infestation.

The three main target species currently present on most of these tracts are: (1) Spotted Knapweed (*Centaurea maculosa*); (2) Dalmation Toadflax (*Linaria dalmatica*); and (3) Leafy Spurge (*Euphorbia esula*). Leafy Spurge is beginning to invade an increasing number of tracts and its spread must be addressed as soon as possible. Dalmatian Toadflax is also problematic. Both of these species were present during site visits in October 2004. Other invasive species might require treatment as well.

Annual application of weed treatment over a lengthy period is needed to ensure the long term success of weed control measures and the subsequent recovery of injured natural resources. The proposed plan covers a 20-year time span, focusing on intensive weed treatment and vegetation restoration, followed by monitoring and continued treatment, if necessary. The BLM will incorporate an adaptive management approach throughout the project to allow greater flexibility and optimization of resources over time. Where feasible, BLM will partner with local agencies and adjacent land owners to leverage resources and encourage a more comprehensive, long-term weed management/restoration program along the Clark Fork River.

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